Relative Abundance, Trends, and Distribution of Water Birds from Aerial Breeding Pair Surveys, 1988 to 2001, on the coastal zone of the Yukon Kuskokwim Delta, Alaska

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Abstract: Fourteen years of annual aerial surveys for breeding waterfowl have been flown on the coastal zone of the Yukon Kuskokwim delta. Northern pintails (*Anas acuta*), greater scaup (*Aythya marila*), and northern shovelers (*Anas clypeata*) were the most numerous waterfowl species averaging 160,403, 80,514, and 37,316 birds, respectively. The average number for three species of special concern, the threatened spectacled eider (*Somateria fisheri*), long-tailed duck (*Clangula hyamelis*), and red-throated loon (*Gavia stellata*) was 8,277, 11,654, and 2,288 respectively. Other waterfowl species in decreasing order of abundance were American green-winged teal (*Anas crecca*), American wigeon (*Anas americana*), mallard (*Anas platyrhynchos*), long-tailed duck, black scoter (*Melanitta nigra*), spectacled eider, common eider (*Somateria mollissima*), and canvasback (*Aythya valisineria*). Very small numbers of goldeneyes (*Bucephala* spp), mergansers (*Mergus* spp), common loons (*Gavia immer*), and red-necked grebes (*Podiceps grisegena*) were seen on the surveys. The average population size for glaucous gull (*Larus hyperboreus*), mew gull (*Larus canus*), and Sabine's gulls (*Xema sabini*) was 42,098, 11,247, and 13,636 respectively. Population trends based on log-linear regression and power analysis were significantly declining for mallards and American wigeon at the 0.10 level. Significantly increasing populations occurred for spectacled eiders, common eiders, greater scaup, and Pacific loons (*Gavia pacifica*). Relative density distribution maps for most species were created using the 1998 - 2001 observation data. Over 68,000 geographic locations of 33 species of water birds have been collected and incorporated into a geographic information system for research and management purposes.

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Annual aerial surveys of breeding water birds on the coastal zone of the Yukon-Kuskokwim Delta, Alaska provide population indices, trends, and distributions for use by biologists and land managers. Since 1985, intensive systematic aerial surveys have been conducted to monitor populations of several goose species that had declined. The initial surveys consisted of a pilot/observer in the left front seat and an additional observer in the right front seat of the aircraft, each counting geese, swans, and cranes.

In 1988, an observer in the right rear seat was added to record other species and begin monitoring their populations. This was done because it was too difficult for the front seat observers to record the large numbers of birds of all species on the Yukon Delta. The objective for the back seat observer was to document the relative abundance, trend, and distribution of ducks, gulls, terns (*Sterna* spp), grebes, jaegers (*Stercorarius* spp.) and loons. These data have been primarily used to monitor the threatened spectacled eider population and other species of concern such as the red-throated loon and long-tailed duck. Our objective in this report is to summarize the population indices and trends for all species recorded by the rear seat observers from 1988 to 2001. We also include relative density distribution maps for most species.

METHODS

Survey Design

The survey area included the coastal tundra from Norton Sound in the north to Kuskokwim Bay in the south and extended from the west coast to about 50km inland. This area was divided into 18 strata by identifying areas of generally homogeneous physiographic features from unclassified LANDSAT images at 1:250,000 scale. The survey was originally designed to optimize monitoring of declining goose populations. We used a True BASIC program and ARC/INFO geographic information system (GIS) software to generate systematically spaced transects from a random coordinate within the survey area. Transects were oriented east west along great circle routes and totaled about 2,500 kms (Fig. 1). Strata known to have higher numbers of waterfowl were allocated more transects. Prior to 1998, we used a 1.61-kilometer transect spacing in the higher density areas. Transects in other strata with fewer waterfowl were spaced at 3.22, 6.44, or 12.88 kilometers. The survey design changed slightly in number and placement of transects over the years. Since 1998, the transects have been spaced at 1.60, 3.20, 6.40, or 12.80 km within the various strata. A different set of transects was flown in each year, 1998-2001, such that we obtained complete coverage in the 1.60 km interval strata when combining data from those four years.

Data Collection

Survey methods followed the conventions established for breeding ground surveys in North America (USFWS and CWS 1987). The surveys were generally flown during the first 2 weeks of June to coincide with egg-laying or early incubation stages of breeding waterfowl (Fig. 2). The Cessna 206 amphibious aircraft was flown at 145 - 170 km per hour, 30 - 46 m of altitude, with wind speed < 24 km per hour, ceilings > 152 m and visibility > 16 km. The pilot used a LORAN (1985 - 1991) or global positioning system (GPS, 1992-2001) and survey maps to maintain a precise course while flying transects.

Data collection prior to 1998 used cassette recorders running continuously while on the transects (Butler et al. 1995). Since 1998, the observer used a computerized data collection program called GPS Voice Survey written by John Hodges (USFWS, Migratory Bird Management, Juneau, Alaska). This system consisted of a notebook computer connected with a GPS receiver and a remote microphone and mouse. The observer recorded transect numbers, start and stop points, cardinal direction of the transect start, and bird observations out to 200 meters into the computer to a .WAV sound file using the remote microphone and mouse. Birds observed were identified to species and counted as a single, pair, or number in flock. Simultaneously, latitude/longitude coordinates for each observation were automatically downloaded from the GPS to a text file. A computer transcription program was used to replay the sound files, enter header information (e.g. year, month, day, observer initials, etc), species codes, group sizes and combine these with the coordinate information to produce a final data file. Karen Bollinger was the observer in 1988 and 1989, Leslie Slater observed in 1990, and Bob Platte has collected the data since 1991.

We collected fourteen years (1988 to 2001) of aerial counts of duck species but data on other water bird species were not collected in all years. Jaegers were recorded in 1989, then 1993 to 2001. Loons were recorded from 1989 to 2001. Gulls and terns were recorded from 1992 to 2001. The back seat observer was unable to collect data on thirteen transects north of the

Askinuk Mountains in 1997. Data from the 1996 survey for those transects were added to the 1997 data set to make up for the missing transects. Twenty three transects were not flown in 1999. Thus, the 1999 population indices may be biased for some strata with missing transects. However, the survey was generally flown by skipping some transects early in the survey, then doing them later to spread the effort out over time. Thus while some transects were missed in some strata in 1999, the transects flown were relatively systematically spaced. The back seat observer was unable to fly thirteen transects in the central coastal zone and the 23 transects north of the Askinuk Mountains in 2001. No data were collected for the 13 mid-coast transects, however, William Eldridge, in the right front seat, recorded observations for all species on the 23 transects north of the Askinuk Mountains. This was accomplished because of the relatively lower number of geese, swans and cranes north of the Askinuk Mountains.

Data Analysis

We calculated densities, population indices, and variability for each species using a ratio estimate described by Cochran (1977). Duck population indices were based on indicated total birds: 2*(S+P)+F where S = number of single birds observed, P = number of bird pairs observed, and F = number of birds in flocks. For ducks, a single male was assumed to represent a breeding pair with the nesting hen not easily observable. Single male ducks were doubled for all observed species except scaup. Single observations of other water bird species (grebes, loons, terns, and gulls) were not doubled. Population indices were calculated for each year for 18 strata and summed for the entire survey area. This stratified analysis was done to try to reduce the variance of the indices. Population index variance was based on the variation among sampling units (entire transects). Population indices in this report were not corrected for visibility bias unless noted.

The population index was plotted for each year by species and included the singles, pairs, and flock components. The 95% confidence interval, indicated by a vertical line, around each annual index was calculated as the ratio estimator variance among the transects (sampling error) within each of the 18 physiographic strata. This sampling standard error divided by the mean index estimated the annual coefficient of variation (CV) of the population index. The average of the estimated annual CVs provided a measure of average survey precision, the sampling error CV. The trend was the average rate of log-linear population change (Stehn 1993). Trend lines were presented for singles/pairs and for indicated total birds (ducks) or observed total birds (species other than ducks).

The residuals around the regression line provided another estimate of survey precision, a residual CV that included both sampling error and lack-of-fit error. A standardized measure of the relative precision of the aerial survey for each species can be calculated from the approximate formula of Gerrodette (1987) that relates sample size, slope, CV, and probabilities for Type 1 and Type 2 errors. With alpha and beta levels at 0.10, if the population began to grow with a slope of 0.0693 (50% change in numbers over 10 years) and the estimated sampling error CV was accurate, the minimum number of survey years needed to detect a slope significantly different from 0.0 was calculated.

GIS Methods

Water bird observations from all years were generated as an ARC/INFO point coverage for use in a GIS. For species with adequate number of observations, the point data from 1998 - 2001 were converted to densities. A grid consisting of 1600 meter by 1600 meter square polygons was overlain on the 200-meter wide flight line polygon strips and the bird points. Number of birds by species and area searched by the strip transects were summed for each square. The bird density for each square was calculated by dividing the bird sum by the area searched sum. The resulting density values were assigned to the centers of the squares. A triangulated irregular network (TIN) was created from the density points. The TIN was then converted to a lattice, which was then contoured. Density polygon classes were determined by the Natural Breaks classification in Arcview of the contours and final density polygons were created from the lattice. The 1600-meter cell size was chosen because that size enabled inclusion of four strip transects (one for each year) in most cells in the 1-mile intensity strata.

RESULTS

Relative abundance

Relative abundance indices by group category for species with sufficient data are shown in Figs. 3 - 22, with long term averages listed in Table 1. None of the population indices in these figures was corrected for visibility bias (detection rate). For the following results, we used the correction factors determined by helicopter-fixed wing aircraft comparisons (Conant et al. 2000). Based on the fourteen-year average population indices for each species corrected for detection rate, the most abundant species was northern pintail (160,403), followed by greater scaup (80,513), then northern shoveler (37,315). The average number for three species of special concern, the threatened spectacled eider, long-tailed duck and red-throated loon, was 8,277, 11,654, and 2,288, respectively. Very small numbers of canvasbacks, goldeneyes, mergansers, common loons, and red-necked grebes were seen on the surveys.

Corrected for visibility, the number of pintails and scaup for 2001 was 126,429 and 86,342, respectively. Remaining species in decreasing order of abundance for 2001 were American green-winged teal, northern shoveler, spectacled eider, mallard, long-tailed duck, black scoter, American wigeon, common eider, canvasback, and red-breasted merganser.

Population trend/power analysis

Of all species for which trends were calculated, only mallards and American wigeon showed a relatively strong decreasing trend (Table 1). Significantly increasing trends occurred for common eiders, spectacled eiders, scaup, and Pacific loons. All other species showed relatively stable trends over the survey period.

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Spectacled eider population and trend

The number of indicated total spectacled eiders from the aerial survey in 2001 was 3,630 birds or 1,815 pairs (uncorrected for visibility bias). The spectacled eider nest population estimate for the entire coastal zone from the ground study in 2001 was 2,102 (Bowman et al. 2001). Corrected with a nest detection rate of 78% (T. Bowman, unpub. data), the nest population estimate was 2,695. Thus the proportion of aerial pairs to nests was 0.67 resulting in a correction factor of 1.48 for aerial visibility bias. However, because of high predation in 2001, the nest estimate was relatively low which could have caused the relatively low correction factor. Additionally, the aerial estimate may have been relatively higher in 2001 because of increased visibility of failed nesters. It is unknown to what degree both of these factors contributed to the high aerial proportion.

The population growth rate for aerial indicated total birds from 1988 to 2001 was 1.073 (Fig. 23). The growth rate for the nest population from ground studies during this same period was 0.98.

Spectacled eider nesting chronology was about 1 week later in 2001 than in 2000 (Bowman et al. 2001). Spectacled eider nest success, mean active clutch size, and number of eggs produced, as determined by the ground nest plot survey (Bowman et al. 2001) were lower in 2001 than many of the previous years of that survey. This was due to high fox predation, late nesting chronology, and a flood tide just after peak hatch (Bowman et al. 2001).

Distribution

Over 68,000 observations of 33 species of water birds have been collected, each with a geographic location. These spatial data have been incorporated into a GIS database for research and management purposes. Average location accuracy of the observations when the surveys were flown using LORAN for navigation was within 367 meters compared to 214 meters when using the GPS (Butler et al. 1995).

Relative density polygon maps for species with sufficient data were created (Figs. 24 - 30). Distributions varied by species. Northern pintails, scaup, arctic terns, glaucous gulls, mew gulls, and Pacific loons tended to be widespread throughout the coastal zone in relatively high numbers. Black scoters, northern shovelers, long-tailed ducks, and mallards were widespread but in scattered, small, isolated patches. Spectacled and common eiders, Sabine's gulls, and red-throated loons were more restricted in their distributions, primarily to the central coastal zone and closer to the coast.

DISCUSSION

Three different observers have collected data for this survey, although the same observer has collected the last 11 years data. All observers were experienced at identifying and counting birds from aircraft, however, there was the possibility of a "learning curve" for some species and that an observer became more skilled over time resulting in more accurate information in later years. Thus, both relative abundance indices and population trends could be affected by this. Trends can be statistically significant but still not reflect actual population change. As the observer gained experience on the area, species identification and counting of groups probably improved. However, the long-term trends were influenced by the low counts in the early years. It is difficult to determine whether the trends reflect actual population growth or are attributable to this or other potential errors in the survey. Strip width may vary both within a survey and between years although an effort was made to be consistent. Some proportion of each species was missed each year due to various factors such as weather. It was assumed that the proportion was constant year to year for the trend calculations. The trends could be biased if this assumption was not true

Timing of surveys was also a factor potentially affecting trend. The survey was supposed to be timed according to annual phenology to coincide with the first half of incubation for geese nesting in the area. However, we were not always able to time our surveys optimally. In some years, surveys were early relative to breeding chronology and phenology, whereas other years surveys were late relative to these factors. To get the best trend information, the surveys should be timed consistently relative to phenology every year. Spectacled eider males begin to depart the breeding grounds shortly after the hens begin incubating so the survey misses an unknown portion of these males. If the survey timing was late relative to phenology, a greater proportion of spectacled eiders had departed resulting in a lower population index for that year (Platte and Stehn 1999). How breeding behavior in other species affects detection rates by aerial observers is unknown.

Trends for red-throated loons and long-tailed ducks on the coastal zone varied from trends on the entire delta determined from the Alaska - Yukon Waterfowl Breeding Population Survey. Red-throated loons appear to have declined at about an average 4% per year from 1989 to 2000 (Conant et al. 2000), whereas the red-throated loon population in the coastal zone appeared stable during this time. The long-tailed duck population in the coastal zone appeared to be increasing slightly in contrast to a decreasing population on the refuge as a whole.

The large number of geographic locations of birds has been useful for a number of purposes. Distribution information has been used to evaluate the coastal zone areas for potential inclusion as designated critical habitat for spectacled eiders. Density distribution maps have been used to evaluate potential land exchange impacts on water birds. Survey information has been incorporated into Birds of North America species accounts for Sabine's gulls. Loon information has been contributed to the Loon Working Group for baseline monitoring and red-throated loon ground work. Seaduck trends were useful for comparison with other information in evaluating population status.

The survey was originally designed to monitor geese. Because the distribution of Cackling Canada geese coincided with that of the spectacled eider, the survey was stratified appropriately for spectacled eiders. However, the sampling intensity was low for other sea duck species because they occurred farther inland, which was sampled only every 12.80 km.

RECOMMENDATIONS

Currently there are two survey efforts to monitor the spectacled eider population on the Yukon Delta: the coastal zone aerial survey and the nest plot survey. Because the nest plot survey does not sample the entire coast, it is necessary to continue the aerial survey to expand the nest estimate. Conversely, since not all eiders are seen from the air, the nest plot study provides a visibility correction factor for the aerial data. We believe these two surveys are highly complementary and provide more detailed information when analyzed together than either one alone for monitoring the spectacled eider population.

The aerial survey provided information on other species of interest. However, the information is limited because these species range beyond the coastal zone. Additionally, long-tailed ducks, scoters, and scaup occur in more inland strata that were not sampled as intensively. If more detailed information is desired for these species we need to allocate more effort in this area. We should examine the effect of decreasing number of transects in high intensity sample strata to determine effect on precision of cackling Canada goose population estimates by subsampling existing data. If these strata could be sampled at a lower rate, then we could increase sampling in inland strata to obtain better information on sea ducks such as long-tailed ducks, black scoters, and greater scaup.

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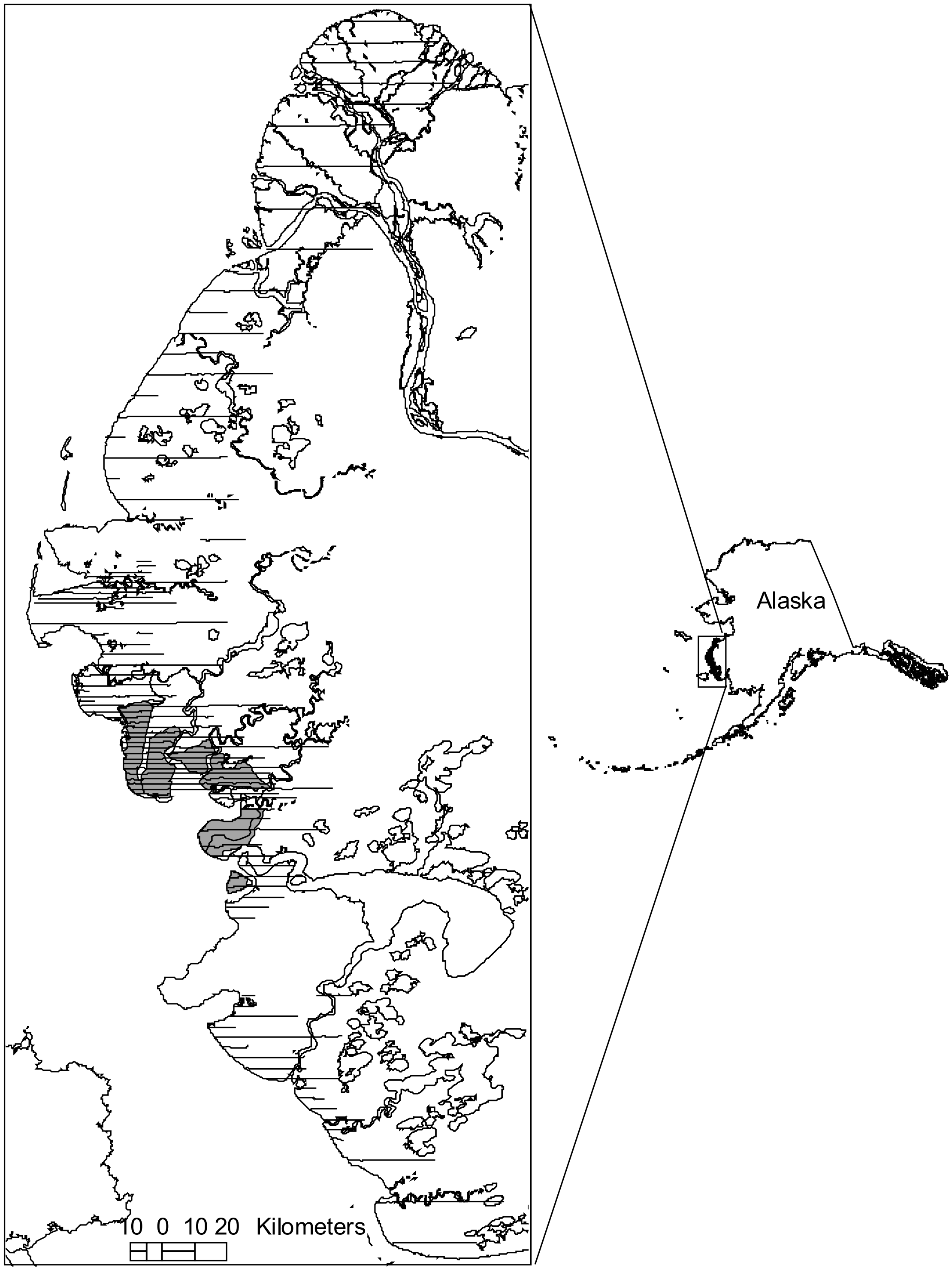

Fig. 1. 2001 aerial strip transects of 200 meter width (horizontal lines) and nest survey area (shaded) on the coastal zone of Yukon Delta NWR, Alaska.

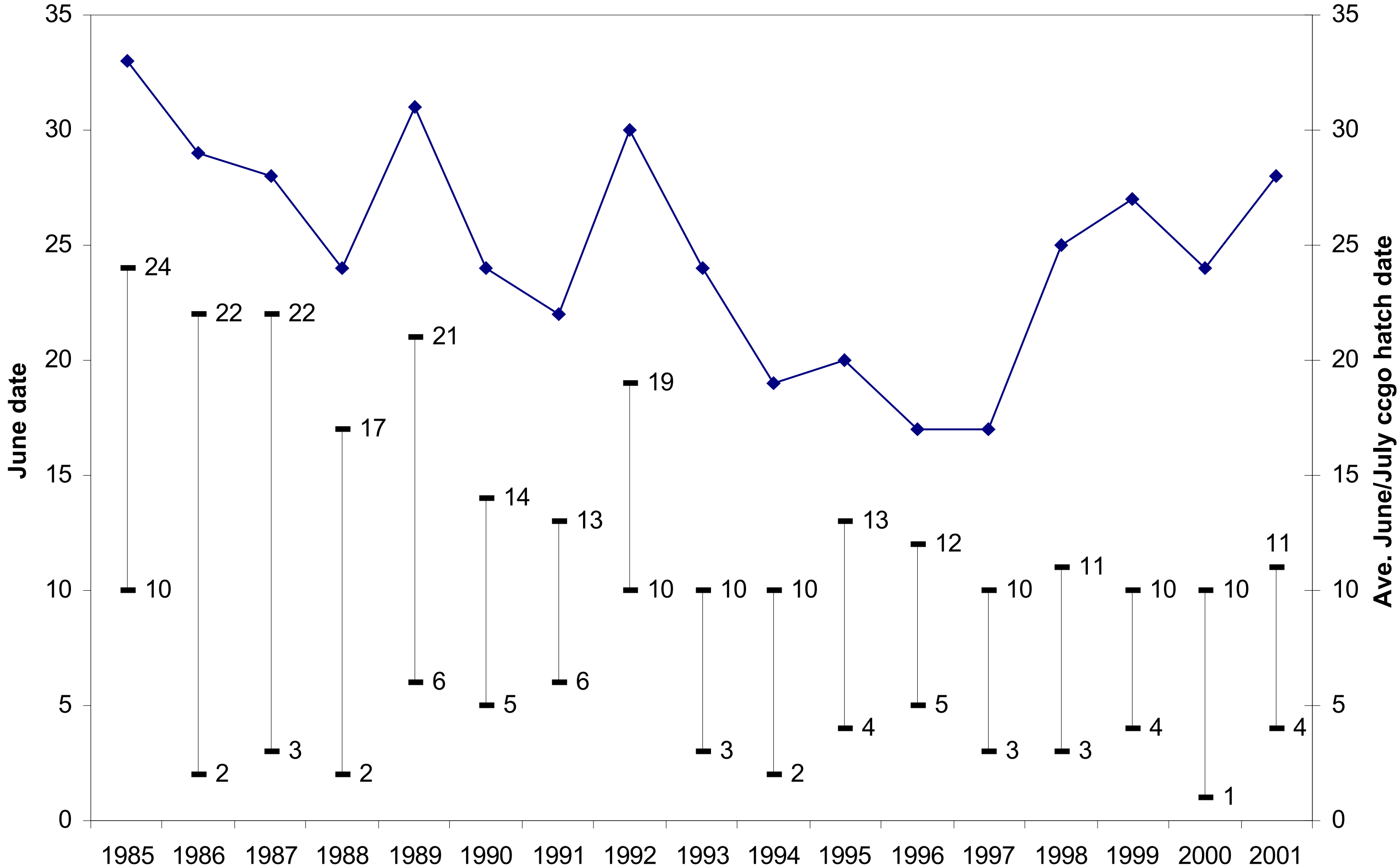

Fig. 2. Timing and duration of the coastal zone aerial survey in relation to average Cackling Canada goose hatch date from ground surveys (Bowman et al. 2001), Yukon-Kuskokwim Delta, Alaska, 1985-2001.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	1,272	602	0	0	1,874	349	1,874	349
1989	1,188	302	0	0	1,490	222	1,490	222
1990	1,450	422	0	0	1,872	284	1,872	284
1991	646	446	0	0	1,093	222	1,093	222
1992	800	318	0	0	1,118	187	1,118	187
1993	1,670	640	0	42	2,310	341	2,352	342
1994	1,484	866	0	0	2,350	329	2,350	329
1995	1,498	1,092	0	0	2,590	395	2,590	395
1996	1,516	852	0	0	2,367	366	2,367	366
1997	1,394	930	0	0	2,324	353	2,324	353
1998	1,906	1,014	0	0	2,920	326	2,920	326
1999	2,702	690	0	0	3,393	493	3,393	493
2000	1,982	1,008	0	0	2,989	314	2,989	314
2001	1,582	2,048	0	0	3,630	432	3,630	432
avg =	1,506	802	0	3	2,309		2,312	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.071	SE=.016	0.071	SE=.016
Prob >Ttest =	0.001		0.001	
power (with alpha at .1) =	1.000		1.000	
min. slope detectable in 14 years =	0.029		0.029	
n years to detect a -0.069 slope =	7.8		7.8	
regression residual error CV =	**0.234**		**0.235**	
average sampling error CV =	**0.149**		**0.149**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.074**	1.047 - 1.101	**1.073**	1.046 - 1.101
avg. growth rate, last 5 yrs =	**1.096**	1.037 - 1.158	**1.096**	1.037 - 1.158

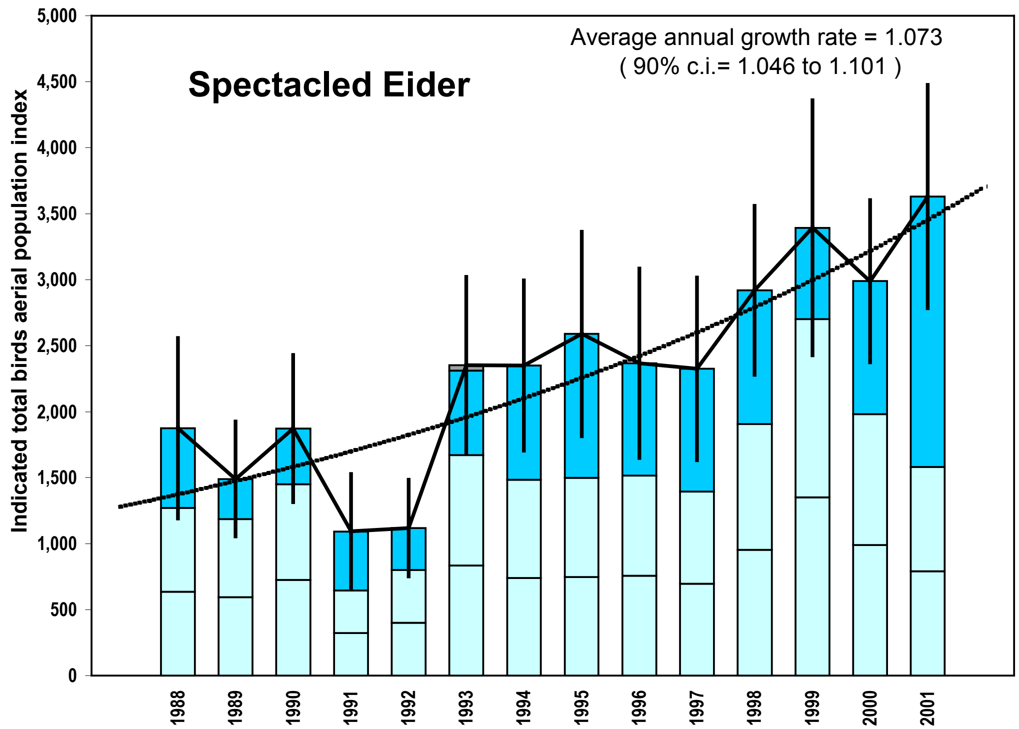

Fig. 3. Population trend for Spectacled Eiders (*Somateria fischeri*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	496	476	33	0	972	272	1,005	275
1989	530	280	0	0	810	267	810	267
1990	324	102	0	0	427	122	427	122
1991	328	232	0	0	559	145	559	145
1992	652	210	0	0	861	181	861	181
1993	588	198	0	42	787	173	829	184
1994	642	312	0	0	954	193	954	193
1995	758	680	0	58	1,438	272	1,496	291
1996	992	572	0	115	1,565	273	1,679	281
1997	1,238	722	0	126	1,959	446	2,085	455
1998	1,064	662	0	0	1,727	278	1,727	278
1999	670	70	0	43	739	195	783	207
2000	870	222	0	0	1,091	213	1,091	213
2001	970	460	0	706	1,430	269	2,136	767
avg =	723	371	2	78	1,094		1,174	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.061	SE=.025	0.073	SE=.026
Prob >Ttest =	0.029		0.015	
power (with alpha at .1) =	0.992		0.999	
min. slope detectable in 14 years =	0.044		0.046	
n years to detect a -0.069 slope =	10.3		10.7	
regression residual error CV =	**0.371**		**0.388**	
average sampling error CV =	**0.228**		**0.239**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.063**	1.021 - 1.107	**1.076**	1.032 - 1.123
avg. growth rate, last 5 yrs =	**0.897**	.727 - 1.106	**0.960**	.739 - 1.246

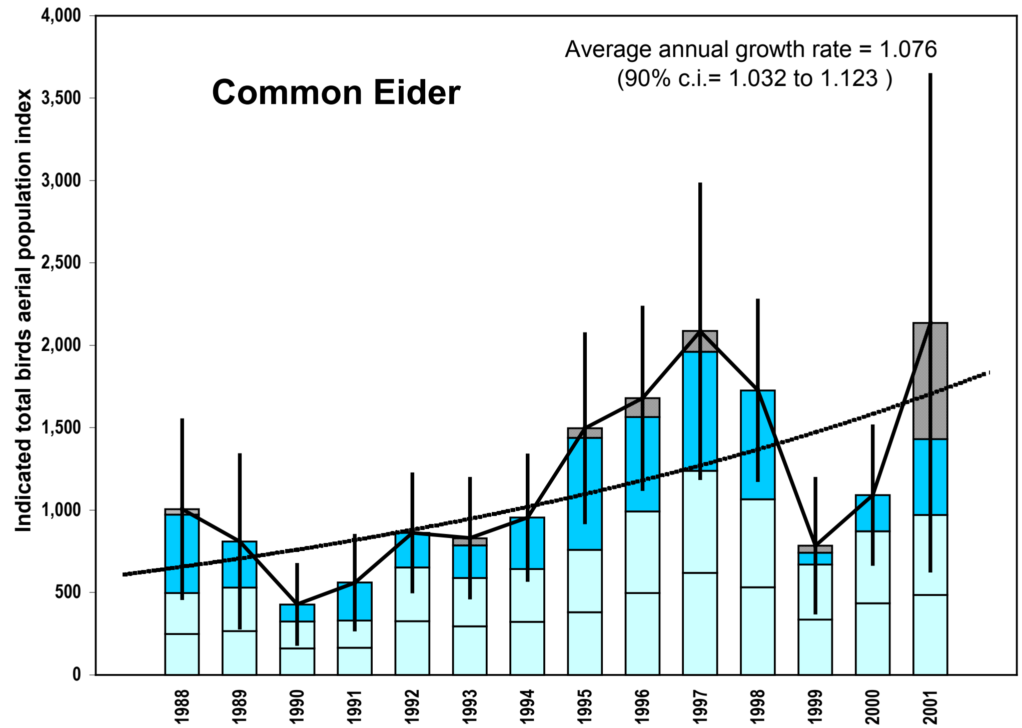

Fig. 4. Population trend for Common Eiders (*Somateria mollisima*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989	1,231	692	25	0	1,923	414	1,949	415
1990	1,400	1,966	194	0	3,367	548	3,560	582
1991	522	486	0	0	1,008	207	1,008	207
1992	1,385	826	398	0	2,210	332	2,608	469
1993	1,737	1,266	0	0	3,002	452	3,002	452
1994	1,288	394	202	0	1,682	234	1,884	312
1995	1,212	1,092	0	0	2,304	402	2,304	402
1996	1,008	1,560	404	0	2,568	544	2,972	597
1997	1,227	894	51	0	2,121	361	2,171	363
1998	1,014	904	0	0	1,919	262	1,919	262
1999	1,307	954	100	0	2,260	345	2,360	358
2000	879	828	32	0	1,706	252	1,738	253
2001	775	1,456	34	0	2,231	359	2,265	362
avg =	1,153	1,024	111	0	2,177		2,288	

	Sg+2*pr		Birds observed	
log-linear slope =	0.000	SE=.023	-0.002	SE=.024
Prob >Ttest =	0.995		0.931	
power (with alpha at .1) =	0.051		0.070	
min. slope detectable in 14 years =	0.036		0.037	
n years to detect a -0.069 slope =	8.418		8.511	
regression residual error CV =	**0.310**		**0.327**	
average sampling error CV =	**0.168**		**0.170**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.000**	.963 - 1.039	**0.998**	.959 - 1.038
avg. growth rate, last 5 yrs =	**0.998**	.93 - 1.072	**0.999**	.926 - 1.077

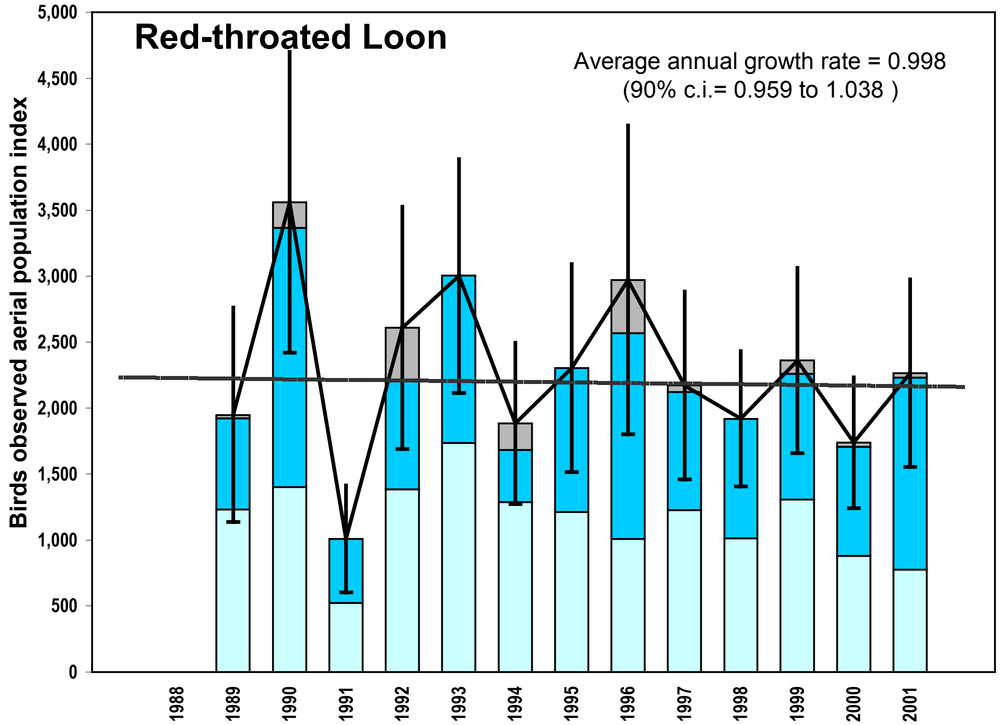

Fig. 5. Population trend for Red-throated Loons (*Gavia stellata*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989	5,751	6,216	90	0	11,966	1,313	12,055	1,317
1990	8,634	8,124	731	212	16,758	1,602	17,701	1,711
1991	8,096	2,928	0	257	11,024	887	11,280	969
1992	8,317	4,592	289	382	12,910	1,042	13,581	1,121
1993	7,849	6,036	222	652	13,885	1,027	14,759	1,298
1994	11,526	6,104	774	81	17,630	1,467	18,485	1,517
1995	10,087	6,402	440	0	16,489	1,380	16,929	1,389
1996	9,808	7,820	178	139	17,628	1,419	17,945	1,428
1997	9,148	7,986	751	638	17,134	1,592	18,523	1,870
1998	5,728	6,402	0	81	12,130	984	12,212	1,004
1999	10,004	12,304	219	442	22,308	1,711	22,970	1,770
2000	9,288	9,438	151	0	18,726	1,644	18,877	1,661
2001	9,248	11,366	1,229	0	20,614	2,346	21,842	2,346
avg =	8,730	7,363	390	222	16,092		16,705	

	Sg+2*pr		Birds observed	
log-linear slope =	0.038	SE=.013	0.038	SE=.014
Prob >Ttest =	0.013		0.019	
power (with alpha at .1) =	1.000		1.000	
min. slope detectable in 14 years =	0.019		0.019	
n years to detect a -0.069 slope =	5.473		5.540	
regression residual error CV =	**0.173**		**0.184**	
average sampling error CV =	**0.088**		**0.089**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.038**	1.017 - 1.061	**1.038**	1.015 - 1.062
avg. growth rate, last 5 yrs =	**1.084**	.961 - 1.222	**1.080**	.947 - 1.23

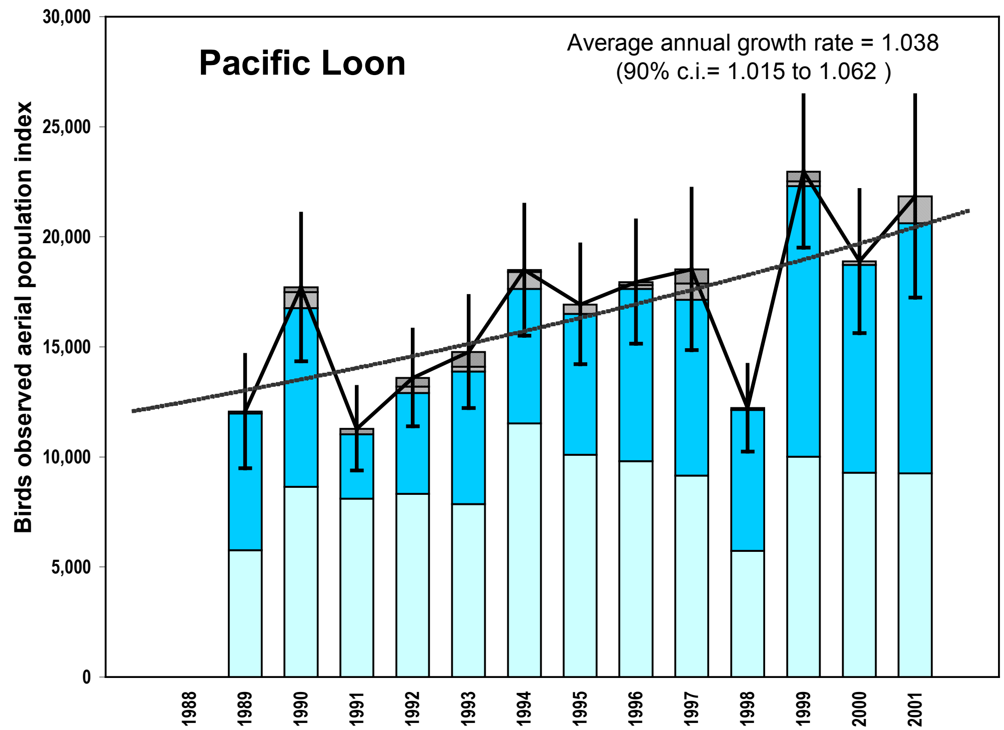

Fig. 6. Population trend for Pacific Loons (*Gavia pacifica*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	3,936	3,200	167	899	7,136	784	8,203	1,205
1989	2,334	1,498	0	1,258	3,832	995	5,090	1,593
1990	3,790	400	0	0	4,191	1,091	4,191	1,091
1991	1,908	614	0	649	2,522	492	3,171	574
1992	3,976	502	0	0	4,477	867	4,477	867
1993	2,404	658	0	0	3,061	698	3,061	698
1994	2,112	454	0	262	2,565	637	2,827	767
1995	4,214	946	0	337	5,160	1,029	5,496	1,117
1996	4,098	334	0	0	4,432	1,070	4,432	1,070
1997	3,314	152	0	50	3,467	718	3,517	719
1998	2,964	670	0	1,096	3,635	831	4,731	1,113
1999	1,698	904	0	0	2,602	573	2,602	573
2000	2,178	334	0	356	2,512	554	2,868	626
2001	1,538	722	0	441	2,261	489	2,702	547
avg =	2,890	813	12	382	3,704		4,098	

	Twice sg+pr		Indicated total birds	
log-linear slope =	-0.046	SE=.019	-0.048	SE=.018
Prob >Ttest =	0.031		0.023	
power (with alpha at .1) =	0.939		0.944	
min. slope detectable in 14 years =	0.042		0.043	
n years to detect a -0.069 slope =	10.0		10.2	
regression residual error CV =	**0.282**		**0.276**	
average sampling error CV =	**0.216**		**0.223**	
		90%c.i.		90%c.i.
average annual growth rate =	**0.955**	.926 - .985	**0.953**	.925 - .983
avg. growth rate, last 5 yrs =	**0.885**	.843 - .928	**0.902**	.807 - 1.009

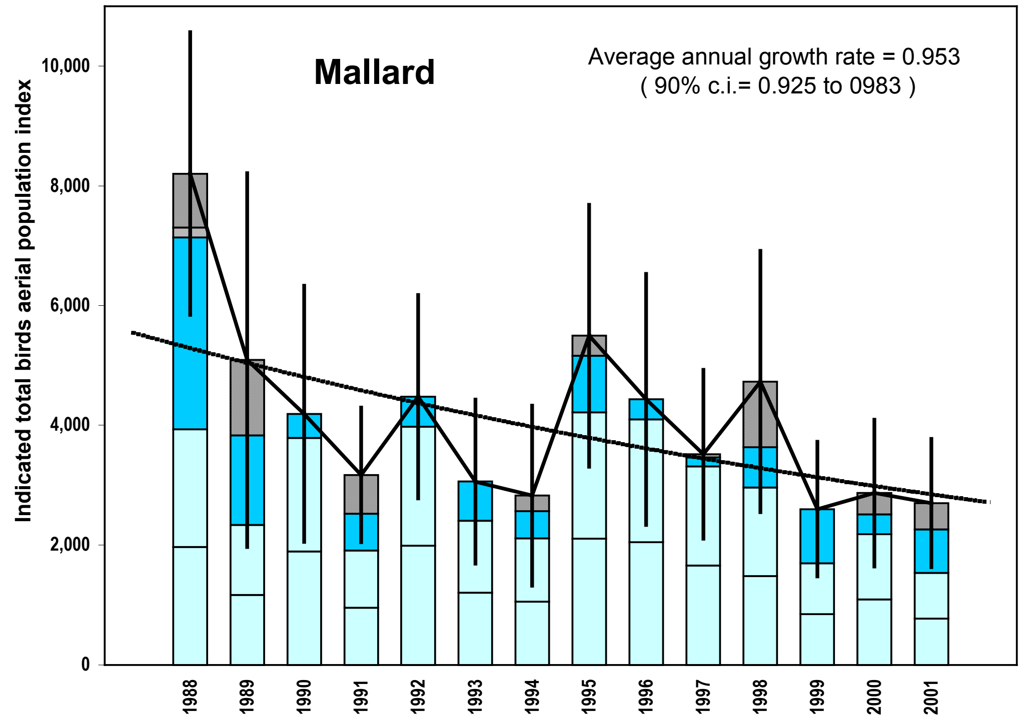

Fig. 7. Population trend for Mallards (*Anas platyrhynchos*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	1,202	1,312	79	4,117	2,512	501	6,708	3,445
1989	1,228	318	0	3,646	1,546	529	5,192	3,102
1990	1,492	142	0	3,890	1,634	354	5,524	2,261
1991	1,404	1,494	0	4,374	2,897	532	7,270	2,235
1992	2,842	864	0	6,435	3,706	456	10,141	2,503
1993	1,830	624	0	1,205	2,454	813	3,658	932
1994	1,430	994	0	3,670	2,426	727	6,096	2,211
1995	1,702	804	0	3,769	2,505	560	6,275	1,825
1996	1,618	384	0	4,267	2,003	506	6,271	3,470
1997	1,854	742	0	5,193	2,597	592	7,790	3,121
1998	732	644	0	5,385	1,376	300	6,761	1,916
1999	640	970	0	744	1,610	428	2,354	606
2000	1,798	592	0	2,373	2,389	600	4,762	1,992
2001	732	666	0	733	1,400	473	2,133	548
avg =	1,465	754	6	3,557	2,218		5,781	

	Twice sg+pr		Indicated total birds	
log-linear slope =	-0.023	SE=.02	-0.052	SE=.026
Prob >Ttest =	0.261		0.070	
power (with alpha at .1) =	0.407		0.690	
min. slope detectable in 14 years =	0.048		0.071	
n years to detect a -0.069 slope =	10.9		14.2	
regression residual error CV =	**0.295**		**0.396**	
average sampling error CV =	**0.248**		**0.368**	
		90%c.i.		90%c.i.
average annual growth rate =	**0.977**	.946 - 1.009	**0.949**	.909 - .991
avg. growth rate, last 5 yrs =	**0.934**	.789 - 1.105	**0.745**	.596 - .932

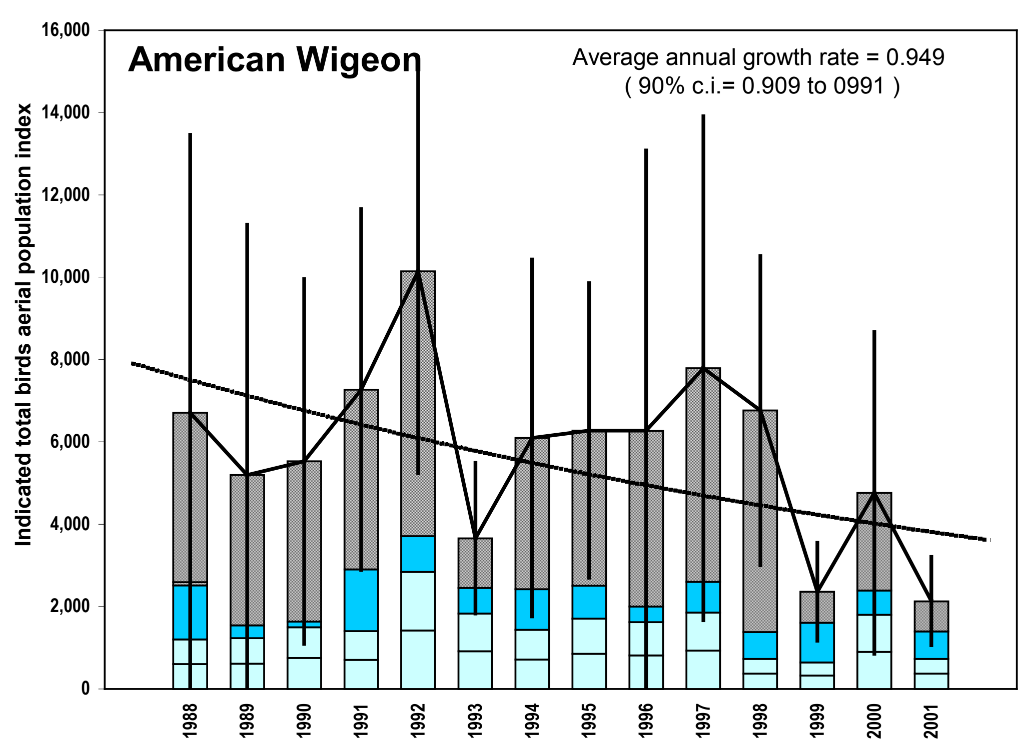

Fig. 8. Population trend for American Wigeon (*Anas americana*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

	Estimated birds observed as:				2(sg+pr)		Indicated total	
year	2*sg	2*pr	flks<5	lg flks	index	SE	index	SE
1988	1,624	1,104	25	410	2,728	465	3,163	554
1989	1,002	312	0	0	1,313	328	1,313	328
1990	1,006	164	0	41	1,171	365	1,212	367
1991	1,370	1,042	0	0	2,412	470	2,412	470
1992	2,038	908	0	0	2,945	472	2,945	472
1993	2,596	836	0	0	3,431	579	3,431	579
1994	3,216	1,024	0	0	4,240	754	4,240	754
1995	2,308	1,128	0	0	3,436	904	3,436	904
1996	1,710	1,372	0	59	3,081	555	3,140	560
1997	2,588	2,004	0	0	4,592	938	4,592	938
1998	1,898	462	0	0	2,360	528	2,360	528
1999	1,798	1,854	0	0	3,652	946	3,652	946
2000	1,210	678	0	0	1,888	443	1,888	443
2001	2,960	1,142	0	0	4,102	590	4,102	590
avg =	1,952	1,002	2	36	2,954		2,992	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.046	SE=.026	0.042	SE=.026
Prob >Ttest =	0.095		0.135	
power (with alpha at .1) =	0.954		0.911	
min. slope detectable in 14 years =	0.041		0.041	
n years to detect a -0.069 slope =	9.8		9.8	
regression residual error CV =	**0.385**		**0.391**	
average sampling error CV =	**0.210**		**0.210**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.047**	1.004 - 1.092	**1.042**	.999 - 1.088
avg. growth rate, last 5 yrs =	**0.956**	.764 - 1.197	**0.956**	.764 - 1.197

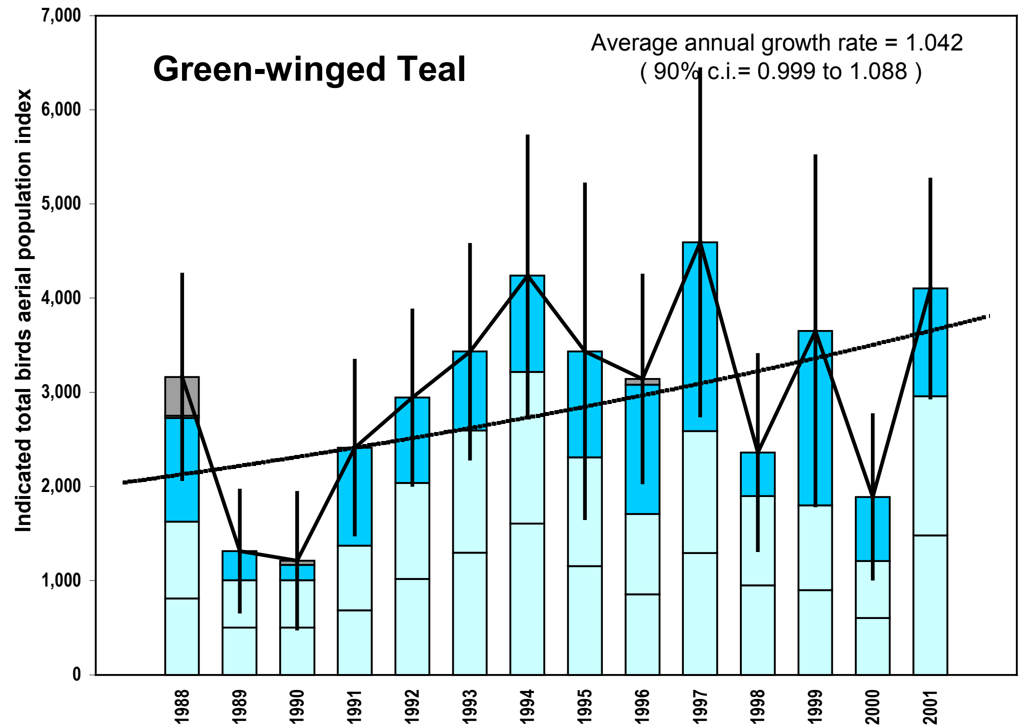

Fig. 9. Population trend for Green-winged Teal (*Anas crecca)* observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as s5tratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	3,620	1,442	0	1,024	5,061	730	6,085	1,180
1989	6,250	2,484	0	639	8,734	1,228	9,373	1,363
1990	5,882	1,260	0	431	7,142	1,179	7,574	1,210
1991	4,754	2,738	0	3,298	7,493	1,015	10,791	2,135
1992	10,234	2,388	0	1,640	12,622	1,593	14,262	1,951
1993	8,326	2,164	0	2,621	10,491	1,875	13,112	2,286
1994	4,162	1,356	0	839	5,519	836	6,358	927
1995	6,952	1,066	0	0	8,018	1,174	8,018	1,174
1996	5,250	1,078	0	3,389	6,327	793	9,716	1,504
1997	4,694	1,652	0	2,866	6,348	1,130	9,214	1,525
1998	13,586	3,270	0	1,204	16,856	1,494	18,060	1,551
1999	5,756	2,418	0	48	8,172	850	8,220	853
2000	6,270	1,396	0	1,740	7,667	1,477	9,406	1,641
2001	4,252	1,888	0	1,510	6,140	1,210	7,650	1,465
avg =	6,428	1,900	0	1,518	8,328		9,846	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.007	SE=.022	0.010	SE=.021
Prob >Ttest =	0.746		0.643	
power (with alpha at .1) =	0.188		0.248	
min. slope detectable in 14 years =	0.029		0.030	
n years to detect a -0.069 slope =	7.8		8.0	
regression residual error CV =	**0.338**		**0.314**	
average sampling error CV =	**0.148**		**0.155**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.007**	.971 - 1.045	**1.010**	.976 - 1.045
avg. growth rate, last 5 yrs =	**0.918**	.728 - 1.158	**0.903**	.753 - 1.082

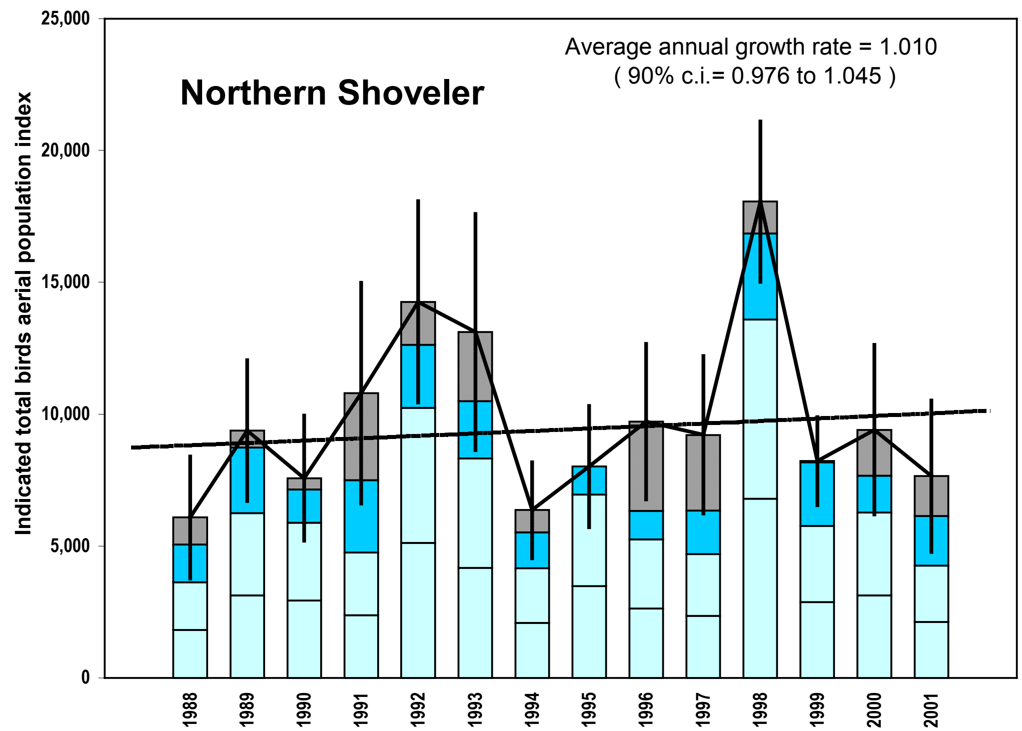

Fig. 10. Population trend for Northern Shovelers (*Anas clypeata*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	29,350	12,110	461	10,133	41,460	3,072	52,053	5,916
1989	24,168	6,324	0	1,470	30,492	2,751	31,962	2,842
1990	44,940	3,638	25	11,060	48,578	3,895	59,662	6,489
1991	33,658	11,812	0	18,780	45,470	3,632	64,250	8,719
1992	55,084	11,048	0	20,139	66,134	3,420	86,272	6,082
1993	25,554	7,122	0	5,703	32,676	2,440	38,379	3,644
1994	28,292	7,988	0	17,055	36,282	3,005	53,337	8,254
1995	36,894	9,572	0	20,095	46,464	3,802	66,560	7,133
1996	27,708	9,590	0	12,549	37,299	2,600	49,848	4,055
1997	27,284	7,670	49	12,472	34,955	3,069	47,476	5,128
1998	33,010	17,790	0	10,064	50,799	2,995	60,864	3,861
1999	24,752	8,774	0	1,855	33,526	3,944	35,381	4,025
2000	33,318	10,488	0	4,973	43,806	4,825	48,779	6,464
2001	19,950	11,492	0	10,010	31,442	2,394	41,452	3,727
avg =	31,712	9,673	38	11,168	41,385		52,591	

	Twice sg+pr		**Indicated total birds**	
log-linear slope =	-0.010	SE=.015	-0.012	SE=.018
Prob >Ttest =	0.500		0.530	
power (with alpha at .1) =	0.612		0.525	
min. slope detectable in 14 years =	0.016		0.020	
n years to detect a -0.069 slope =	5.2		6.2	
regression residual error CV =	**0.225**		**0.275**	
average sampling error CV =	**0.081**		**0.105**	
		90%c.i.		90%c.i.
average annual growth rate =	**0.990**	.966 - 1.014	**0.988**	.959 - 1.018
avg. growth rate, last 5 yrs =	**0.965**	.859 - 1.084	**0.952**	.851 - 1.064

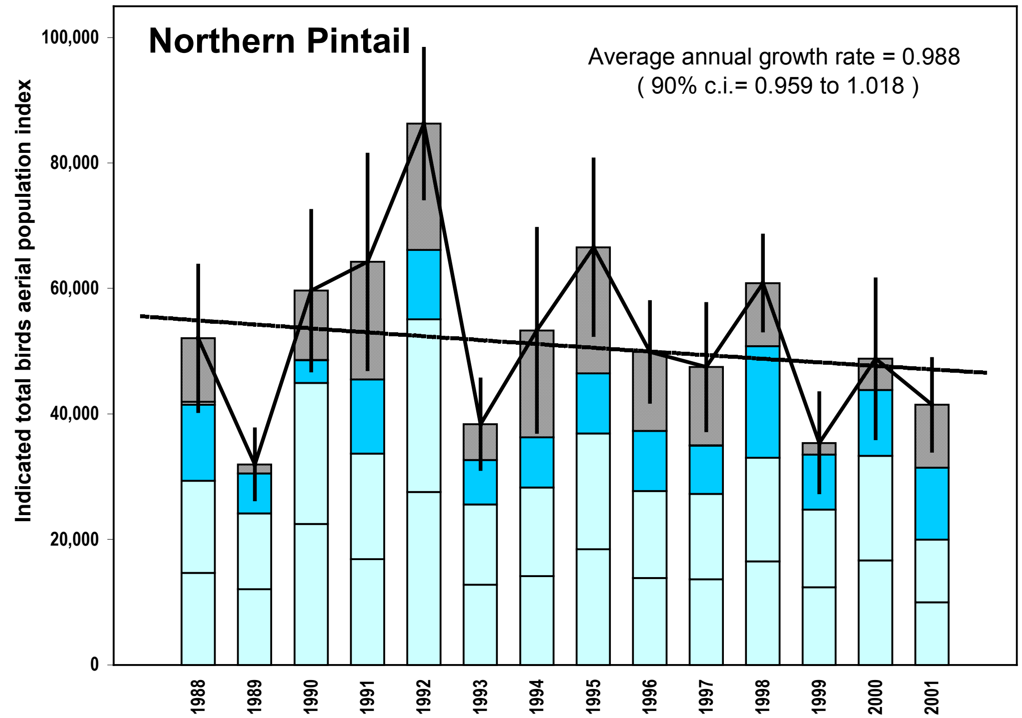

Fig. 11. Population trend for Northern Pintails (*Anas acuta*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	268	334	0	502	601	212	1,103	555
1989	1,124	516	0	0	1,641	506	1,641	506
1990	718	386	0	1,111	1,105	377	2,215	1,301
1991	566	168	0	46	735	345	781	347
1992	1,438	172	0	0	1,609	1,058	1,609	1,058
1993	1,238	136	0	614	1,374	670	1,988	757
1994	332	178	0	331	510	208	840	334
1995	648	0	0	194	649	331	843	399
1996	104	144	0	0	249	151	249	151
1997	0	90	0	0	89	72	89	72
1998	502	342	0	319	844	322	1,164	459
1999	546	1,276	0	0	1,823	516	1,823	516
2000	364	158	0	409	522	175	931	318
2001	406	200	0	397	606	258	1,002	449
avg =	590	293	0	280	883		1,163	

	Twice sg+pr		Indicated total birds	
log-linear slope =	-0.058	SE=.054	-0.060	SE=.057
Prob >Ttest =	0.300		0.319	
power (with alpha at .1) =	0.610		0.602	
min. slope detectable in 14 years =	0.088		0.092	
n years to detect a -0.069 slope =	16.4		16.8	
regression residual error CV =	**0.808**		**0.865**	
average sampling error CV =	**0.456**		**0.474**	
		90%c.i.		90%c.i.
average annual growth rate =	**0.944**	.864 - 1.031	**0.942**	.857 - 1.035
avg. growth rate, last 5 yrs =	**1.399**	.778 - 2.515	**1.587**	.905 - 2.785

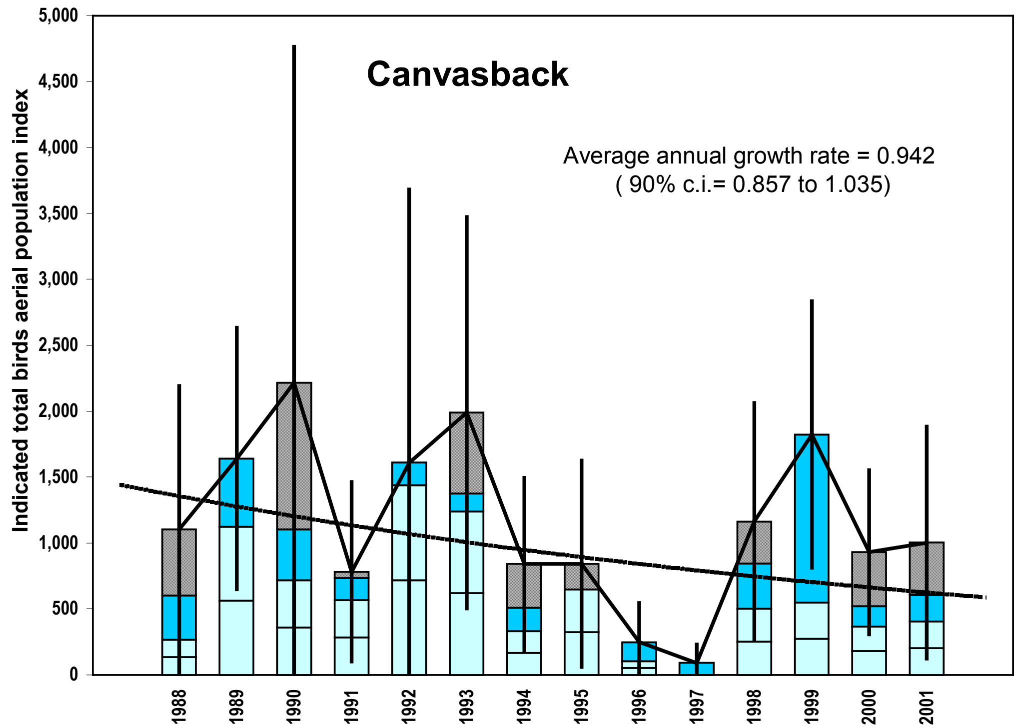

Fig. 12. Population trend for Canvasbacks (*Aythya valisineria*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	10,382	21,434	660	1,062	31,816	2,923	33,538	2,892
1989	7,998	19,674	0	1,107	27,672	3,587	28,779	4,421
1990	9,000	21,698	72	4,624	30,699	4,347	35,395	5,993
1991	7,800	18,230	0	6,623	26,029	2,132	32,652	3,651
1992	15,072	19,474	0	1,962	34,546	2,676	36,508	3,104
1993	12,148	31,656	0	4,668	43,804	4,347	48,472	6,347
1994	10,660	33,778	0	3,196	44,439	3,681	47,635	4,492
1995	15,564	32,556	0	3,745	48,120	4,423	51,865	5,156
1996	13,000	31,166	0	1,590	44,166	2,653	45,756	2,875
1997	14,360	25,312	0	2,788	39,673	2,862	42,460	3,273
1998	9,492	31,766	0	7,204	41,257	4,046	48,461	5,269
1999	12,800	29,074	0	1,237	41,875	2,877	43,112	3,142
2000	14,108	28,458	0	2,097	42,565	3,269	44,663	3,596
2001	7,052	34,638	0	3,047	41,690	4,337	44,737	4,561
avg =	11,388	27,065	52	3,211	38,454		41,717	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.033	SE=.009	0.030	SE=.009
Prob >Ttest =	0.004		0.005	
power (with alpha at .1) =	1.000		0.998	
min. slope detectable in 14 years =	0.018		0.020	
n years to detect a -0.069 slope =	5.6		6.1	
regression residual error CV =	**0.142**		**0.132**	
average sampling error CV =	**0.091**		**0.103**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.034**	1.018 - 1.05	**1.031**	1.016 - 1.046
avg. growth rate, last 5 yrs =	**1.013**	1.003 - 1.023	**1.002**	.972 - 1.033

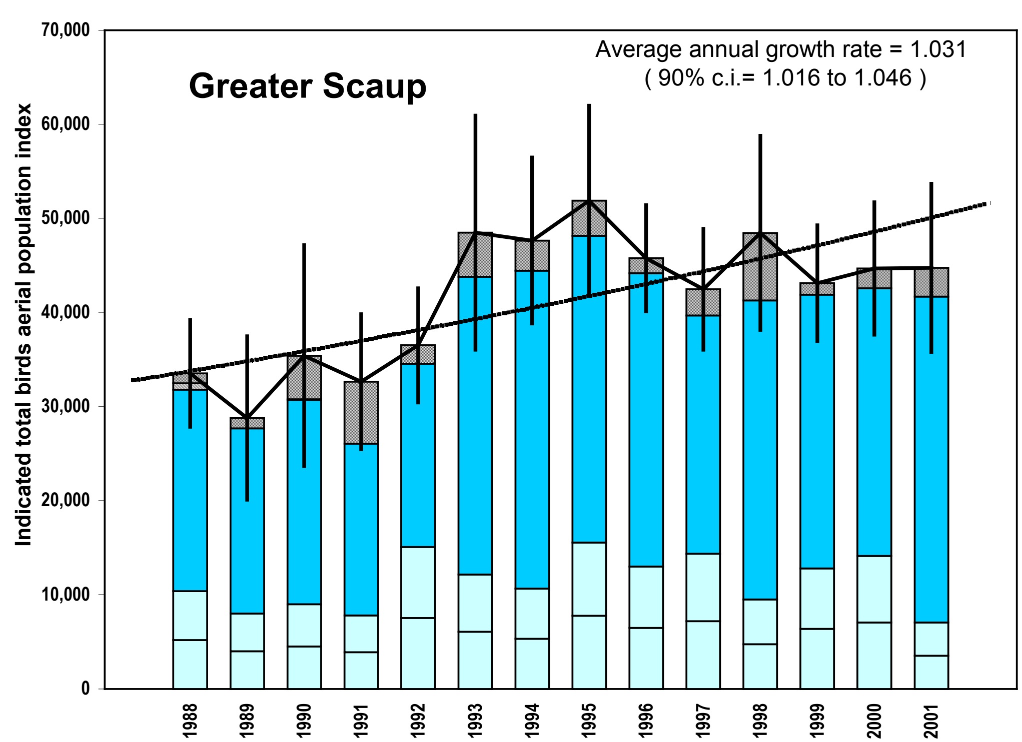

Fig. 13. Population trend for Greater Scaup (*Aythya marila*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	120	384	303	292	505	265	1,099	439
1989	72	16	0	0	89	52	89	52
1990	0	0	0	0	0	0	10	0
1991	0	0	0	0	0	0	10	0
1992	168	0	0	548	169	158	717	538
1993	0	0	0	0	0	0	10	0
1994	0	0	0	0	0	0	10	0
1995	0	0	0	0	0	0	10	0
1996	0	0	0	0	0	0	10	0
1997	0	0	0	0	0	0	10	0
1998	0	0	0	0	0	0	10	0
1999	0	0	0	0	0	0	10	0
2000	0	0	0	0	0	0	10	0
2001	0	0	0	0	0	0	10	0
avg =	26	29	22	60	55		144	

	Twice sg+pr		Indicated total birds	
log-linear slope =	-0.196	SE=.071	-0.234	SE=.093
Prob >Ttest =	0.017		0.027	
power (with alpha at .1) =	1.000		1.000	
min. slope detectable in 14 years =	0.028		0.024	
n years to detect a -0.069 slope =	7.7		6.9	
regression residual error CV =	**1.069**		**1.407**	
average sampling error CV =	**0.147**		**0.124**	
		90%c.i.		90%c.i.
average annual growth rate =	**0.822**	.732 - .924	**0.791**	.679 - .923
avg. growth rate, last 5 yrs =	**1.000**	1. - 1.	**1.000**	1. - 1.

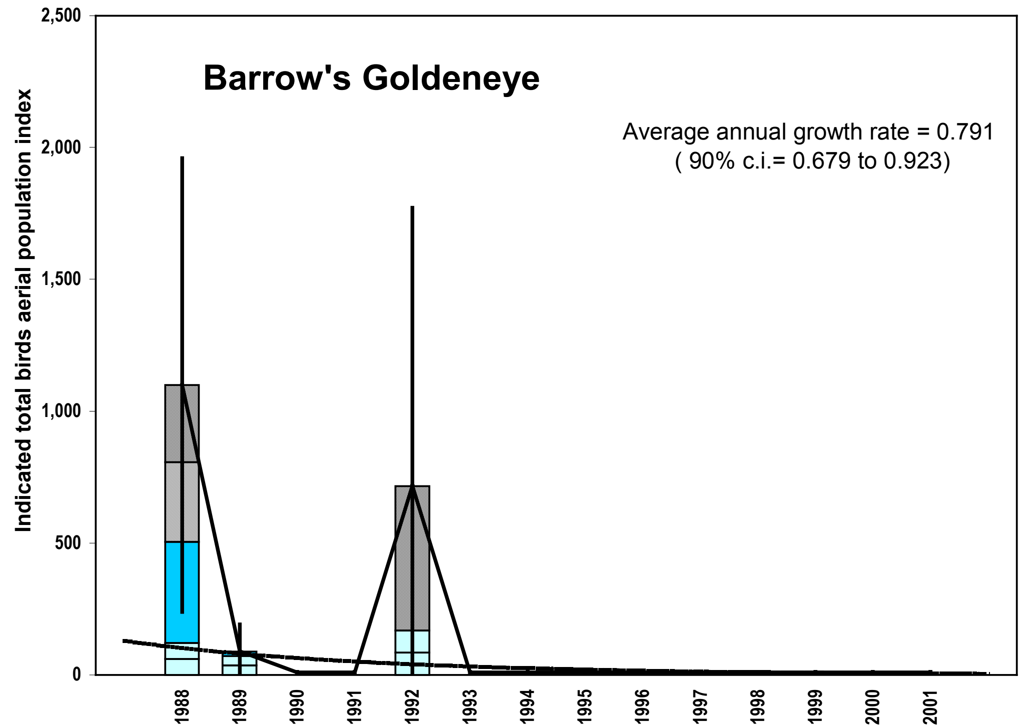

Fig. 14. Population trend for Barrow's Goldeneye (*Bucephala islandica*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	2,942	1,330	0	451	4,272	812	4,723	882
1989	2,316	704	0	0	3,020	661	3,020	661
1990	2,592	2,304	0	0	4,897	757	4,897	757
1991	3,720	1,512	0	211	5,232	544	5,443	643
1992	5,120	1,714	0	0	6,834	690	6,834	690
1993	6,062	3,598	0	100	9,659	1,193	9,759	1,199
1994	3,342	3,434	0	0	6,776	833	6,776	833
1995	4,364	3,162	0	0	7,525	838	7,525	838
1996	4,388	2,400	0	0	6,789	939	6,789	939
1997	5,306	2,746	0	0	8,053	801	8,053	801
1998	4,100	2,550	0	0	6,649	1,148	6,649	1,148
1999	2,608	2,762	0	0	5,370	827	5,370	827
2000	2,308	3,668	0	0	5,977	795	5,977	795
2001	2,002	3,268	0	169	5,270	702	5,439	675
avg =	3,655	2,511	0	67	6,166		6,232	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.028	SE=.018	0.025	SE=.018
Prob >Ttest =	0.157		0.190	
power (with alpha at .1) =	0.912		0.857	
min. slope detectable in 14 years =	0.027		0.027	
n years to detect a -0.069 slope =	7.5		7.5	
regression residual error CV =	**0.277**		**0.272**	
average sampling error CV =	**0.140**		**0.140**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.028**	.998 - 1.06	**1.025**	.995 - 1.056
avg. growth rate, last 5 yrs =	**0.909**	.862 - .958	**0.915**	.866 - .966

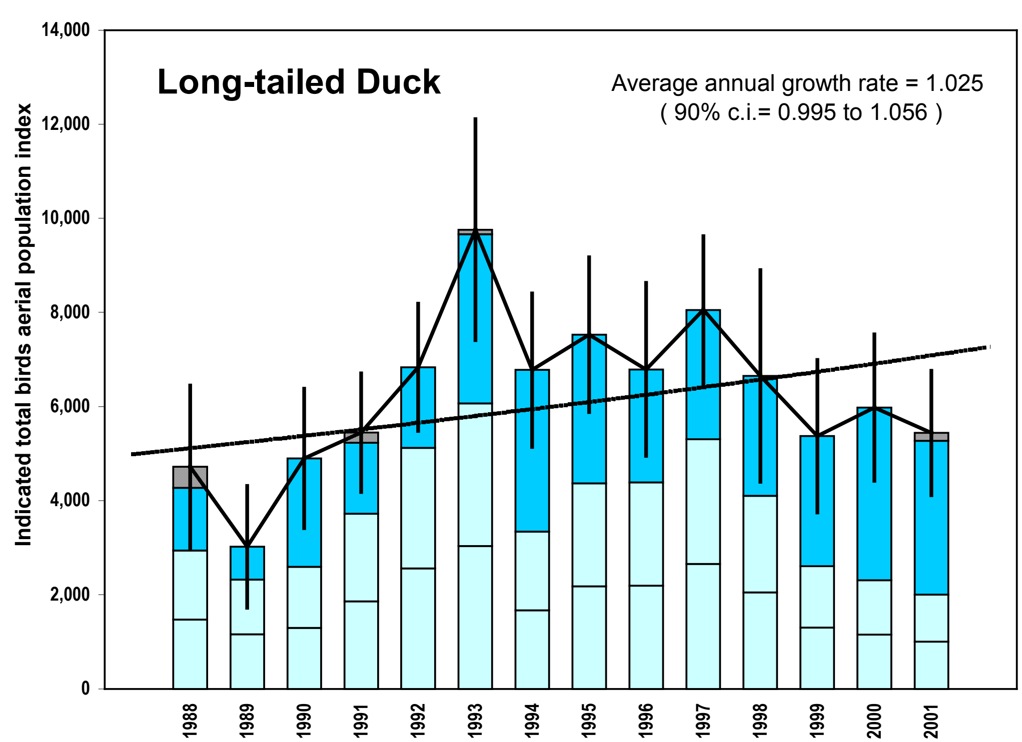

Fig. 15. Population trend for Long-tailed Ducks (*Clangula hyamelis*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	2,364	5,492	773	902	7,856	966	9,531	1,329
1989	2,188	6,938	0	0	9,124	3,225	9,124	3,225
1990	2,172	5,194	0	1,267	7,364	1,141	8,631	1,729
1991	432	2,318	0	165	2,751	557	2,915	599
1992	1,380	7,574	0	286	8,954	1,159	9,240	1,179
1993	3,904	8,440	0	1,269	12,344	1,855	13,613	2,285
1994	3,318	7,628	0	1,482	10,945	2,349	12,427	2,810
1995	1,516	8,608	0	934	10,124	1,672	11,057	1,855
1996	2,236	8,638	0	59	10,874	1,374	10,934	1,374
1997	2,506	9,240	0	81	11,745	2,147	11,826	2,150
1998	2,332	6,598	0	291	8,930	1,303	9,220	1,308
1999	1,414	6,850	0	999	8,265	1,383	9,264	1,928
2000	1,666	11,720	0	142	13,387	4,021	13,529	4,023
2001	1,296	5,946	0	676	7,242	1,071	7,917	1,155
avg =	2,052	7,227	55	611	9,279		9,945	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.029	SE=.025	0.024	SE=.025
Prob >Ttest =	0.267		0.352	
power (with alpha at .1) =	0.781		0.607	
min. slope detectable in 14 years =	0.035		0.037	
n years to detect a -0.069 slope =	8.9		9.2	
regression residual error CV =	**0.380**		**0.379**	
average sampling error CV =	**0.183**		**0.192**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.030**	.988 - 1.073	**1.025**	.983 - 1.068
avg. growth rate, last 5 yrs =	**0.945**	.819 - 1.091	**0.959**	.848 - 1.084

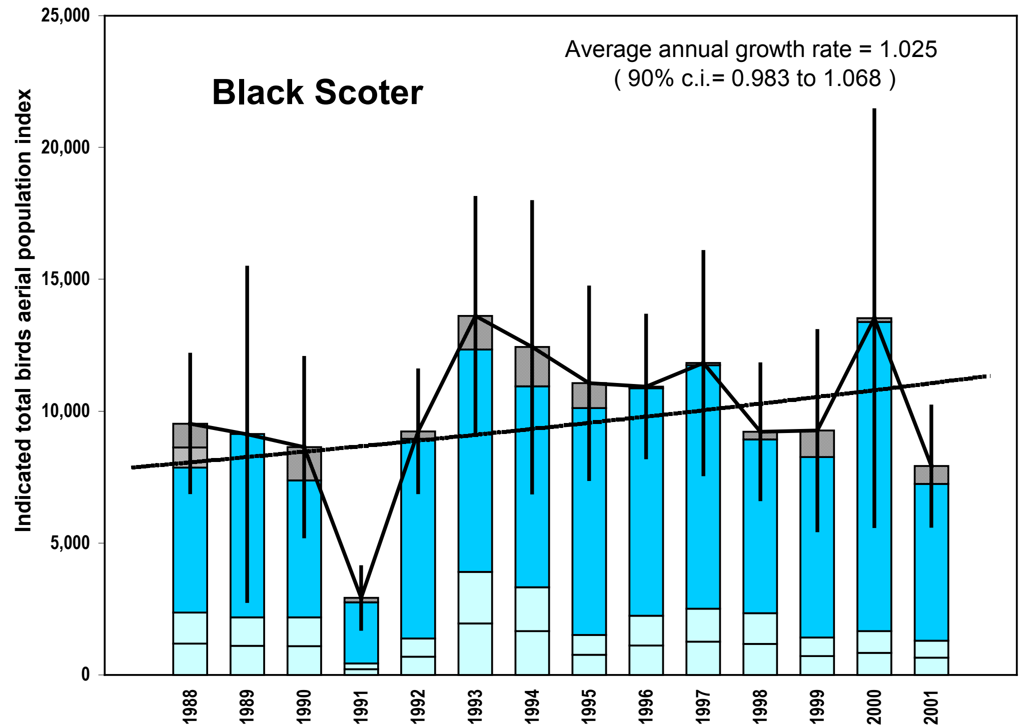

Fig. 16. Population trend for Black Scoters (*Melanitta nigra*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: 2*sg	2*pr	flks<5	lg flks	2(sg+pr) index	SE	Indicated total index	SE
1988	236	196	41	0	432	188	473	193
1989	104	0	0	0	104	69	104	69
1990	0	66	0	0	66	67	66	67
1991	18	164	0	0	182	98	182	98
1992	74	152	0	0	226	75	226	75
1993	164	146	0	0	310	128	310	128
1994	344	572	0	0	917	253	917	253
1995	576	344	0	127	920	425	1,047	444
1996	140	240	0	0	380	116	380	116
1997	252	166	0	83	417	153	500	170
1998	358	146	0	0	503	178	503	178
1999	980	1,072	0	0	2,052	683	2,052	683
2000	248	636	0	0	885	595	885	595
2001	446	1,184	0	0	1,630	555	1,630	555
avg =	281	363	3	15	645		663	

	Twice sg+pr		Indicated total birds	
log-linear slope =	0.181	SE=.044	0.181	SE=.045
Prob >Ttest =	0.001		0.002	
power (with alpha at .1) =	1.000		1.000	
min. slope detectable in 14 years =	0.090		0.088	
n years to detect a -0.069 slope =	16.6		16.4	
regression residual error CV =	**0.660**		**0.676**	
average sampling error CV =	**0.464**		**0.457**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.199**	1.116 - 1.288	**1.199**	1.113 - 1.29
avg. growth rate, last 5 yrs =	**1.390**	1.049 - 1.842	**1.340**	1.016 - 1.767

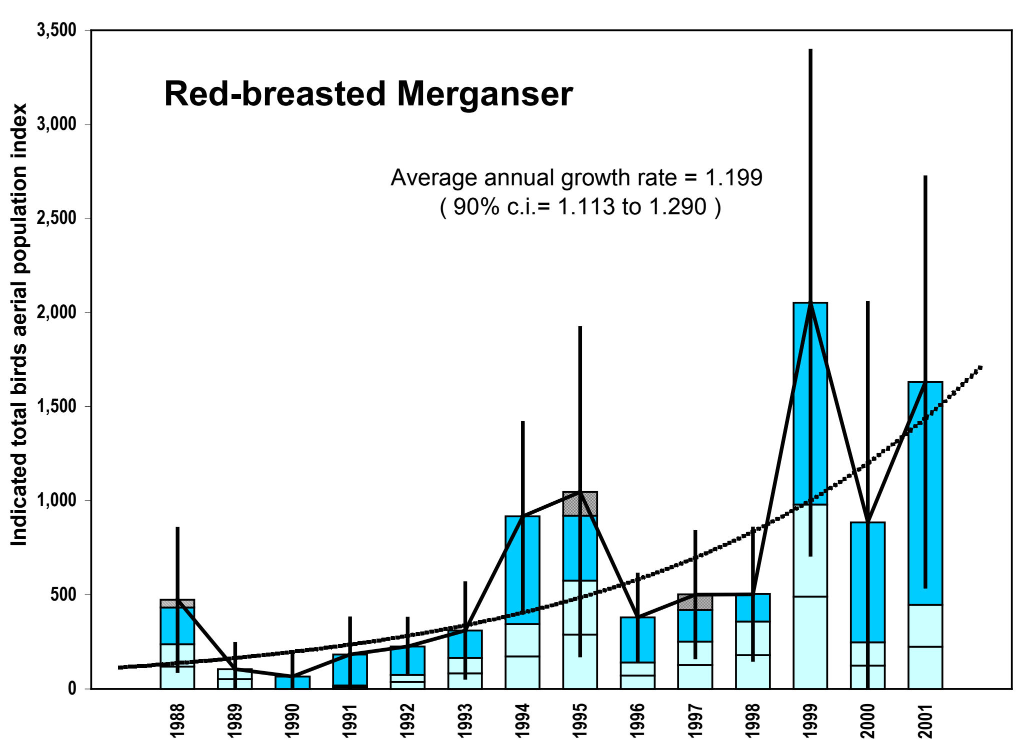

Fig. 17. Population trend for Red-breasted Mergansers (*Mergus serrator*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The indicated-total-birds aerial population index is the sum of singles, indicated singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989	1,708	160	0	0	1,869	271	1,869	271
1990								
1991								
1992								
1993	1,857	664	159	0	2,520	458	2,679	455
1994	2,055	316	426	0	2,371	342	2,797	530
1995	2,498	690	97	192	3,188	483	3,477	536
1996	1,438	440	0	0	1,878	342	1,878	342
1997	1,231	428	0	0	1,660	388	1,660	388
1998	1,539	342	87	0	1,881	345	1,968	348
1999	1,812	338	58	211	2,150	372	2,419	430
2000	2,168	120	0	0	2,288	322	2,288	322
2001	1,505	454	97	0	1,958	311	2,055	341
avg =	1,781	395	92	40	2,176		2,309	

	Sg+2*pr		Birds observed	
log-linear slope =	-0.007	SE=.018	-0.007	SE=.022
Prob >Ttest =	0.715		0.753	
power (with alpha at .1) =	0.102		0.102	
min. slope detectable in 14 years =	0.054		0.056	
n years to detect a -0.069 slope =	8.484		8.620	
regression residual error CV =	**0.200**		**0.238**	
average sampling error CV =	**0.170**		**0.174**	
		90%c.i.		90%c.i.
average annual growth rate =	**0.993**	.963 - 1.024	**0.993**	.958 - 1.029
avg. growth rate, last 5 yrs =	**1.054**	.997 - 1.114	**1.059**	.989 - 1.135

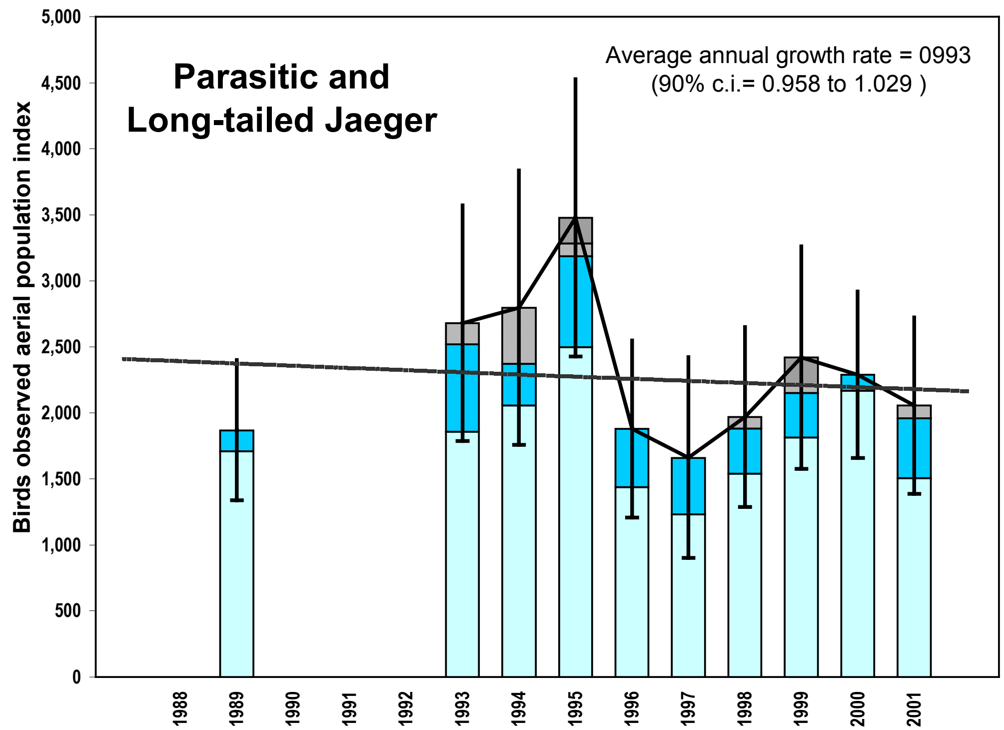

Fig. 18. Population trend for jaeger species (*Stercorarius parasiticus, Stercorarius longicaudus*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989								
1990								
1991								
1992	4,881	3,480	2,700	21,160	8,360	1,132	32,221	6,857
1993	4,938	4,726	2,719	18,305	9,664	797	30,688	5,275
1994	5,243	4,790	2,413	21,501	10,033	896	33,947	5,663
1995	5,337	4,634	2,481	23,732	9,970	832	36,183	6,691
1996	6,283	4,384	2,326	31,392	10,667	735	44,385	9,110
1997	6,170	4,960	2,861	53,199	11,130	876	67,190	12,003
1998	7,180	7,178	4,436	45,699	14,358	1,877	64,493	13,138
1999	5,101	4,442	1,679	12,769	9,543	985	23,992	4,083
2000	7,081	7,042	2,816	21,992	14,122	1,088	38,930	5,453
2001	5,797	7,728	3,637	31,787	13,525	1,318	48,950	11,358
avg =	5,801	5,336	2,807	28,154	11,137		42,098	

	Sg+2*pr		Birds observed	
log-linear slope =	0.048	SE=.013	0.035	SE=.036
Prob >Ttest =	0.008		0.356	
power (with alpha at .1) =	0.998		0.534	
min. slope detectable in 14 years =	0.030		0.060	
n years to detect a -0.069 slope =	5.749		9.048	
regression residual error CV =	**0.122**		**0.328**	
average sampling error CV =	**0.095**		**0.187**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.049**	1.026 - 1.072	**1.036**	.976 - 1.099
avg. growth rate, last 5 yrs =	**1.038**	.939 - 1.148	**0.892**	.71 - 1.122

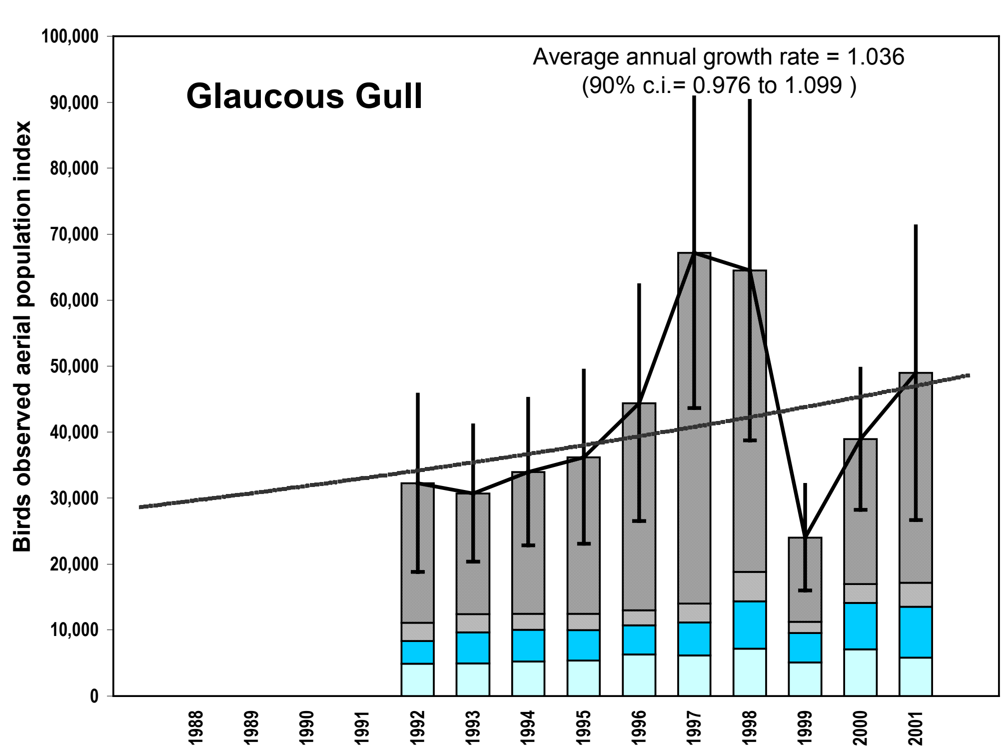

Fig. 19. Population trend for Glaucous Gulls (*Larus hyberboreus*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989								
1990								
1991								
1992	3,025	1,792	748	1,846	4,817	591	7,411	1,359
1993	2,349	1,634	367	2,312	3,984	469	6,663	1,459
1994	4,494	1,626	1,705	2,041	6,120	609	9,866	1,368
1995	5,915	5,146	1,244	3,746	11,061	1,213	16,051	2,279
1996	3,806	2,652	943	5,449	6,457	714	12,849	2,785
1997	4,232	2,656	1,063	2,263	6,887	615	10,213	1,266
1998	4,157	2,914	1,603	7,250	7,072	589	15,925	2,691
1999	4,588	2,928	1,572	2,195	7,517	1,105	11,284	1,997
2000	6,038	2,390	645	2,627	8,427	772	11,700	1,447
2001	4,500	3,252	824	1,936	7,751	613	10,512	1,487
avg =	4,310	2,699	1,071	3,167	7,009		11,247	

	Sg+2*pr		Birds observed	
log-linear slope =	0.056	SE=.027	0.045	SE=.029
Prob >Ttest =	0.068		0.158	
power (with alpha at .1) =	0.999		0.815	
min. slope detectable in 14 years =	0.034		0.052	
n years to detect a -0.069 slope =	6.171		8.282	
regression residual error CV =	**0.242**		**0.265**	
average sampling error CV =	**0.105**		**0.164**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.058**	1.012 - 1.105	**1.047**	.997 - 1.098
avg. growth rate, last 5 yrs =	**1.042**	1.014 - 1.071	**0.975**	.879 - 1.082

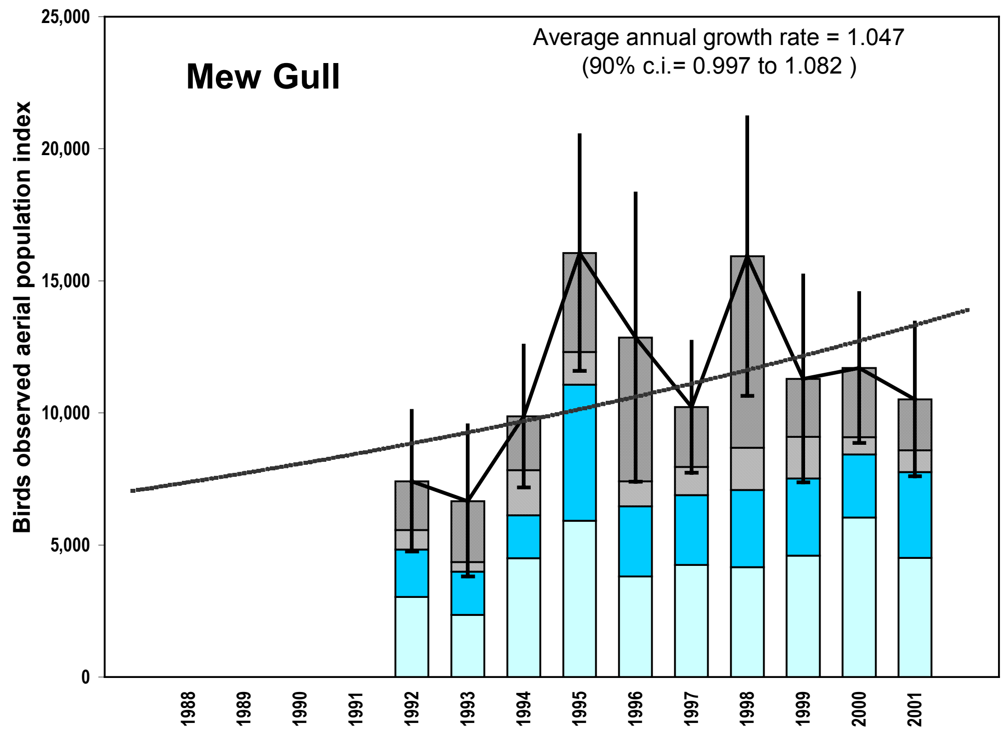

Fig. 20. Population trend for Mew Gulls (*Larus canus*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989								
1990								
1991								
1992	2,846	1,404	803	1,839	4,250	439	6,893	688
1993	3,327	2,560	1,578	3,521	5,887	564	10,986	1,318
1994	3,847	1,860	1,296	6,034	5,707	380	13,037	1,511
1995	4,651	3,212	1,696	3,986	7,862	629	13,544	1,887
1996	3,863	2,622	1,701	6,687	6,486	569	14,874	2,060
1997	5,108	3,532	1,974	13,140	8,640	698	23,754	4,126
1998	3,226	2,502	968	1,738	5,729	690	8,435	909
1999	3,741	1,594	991	1,244	5,335	453	7,570	778
2000	5,641	3,404	2,201	4,391	9,044	687	15,636	1,481
2001	5,975	4,100	2,493	9,067	10,075	975	21,635	3,204
avg =	4,223	2,679	1,570	5,165	6,902		13,636	

	Sg+2*pr		Birds observed	
log-linear slope =	0.059	SE=.024	0.055	SE=.045
Prob >Ttest =	0.040		0.254	
power (with alpha at .1) =	1.000		0.992	
min. slope detectable in 14 years =	0.029		0.040	
n years to detect a -0.069 slope =	5.540		6.897	
regression residual error CV =	**0.219**		**0.407**	
average sampling error CV =	**0.089**		**0.124**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.061**	1.02 - 1.104	**1.057**	.982 - 1.138
avg. growth rate, last 5 yrs =	**1.079**	.923 - 1.263	**1.044**	.762 - 1.43

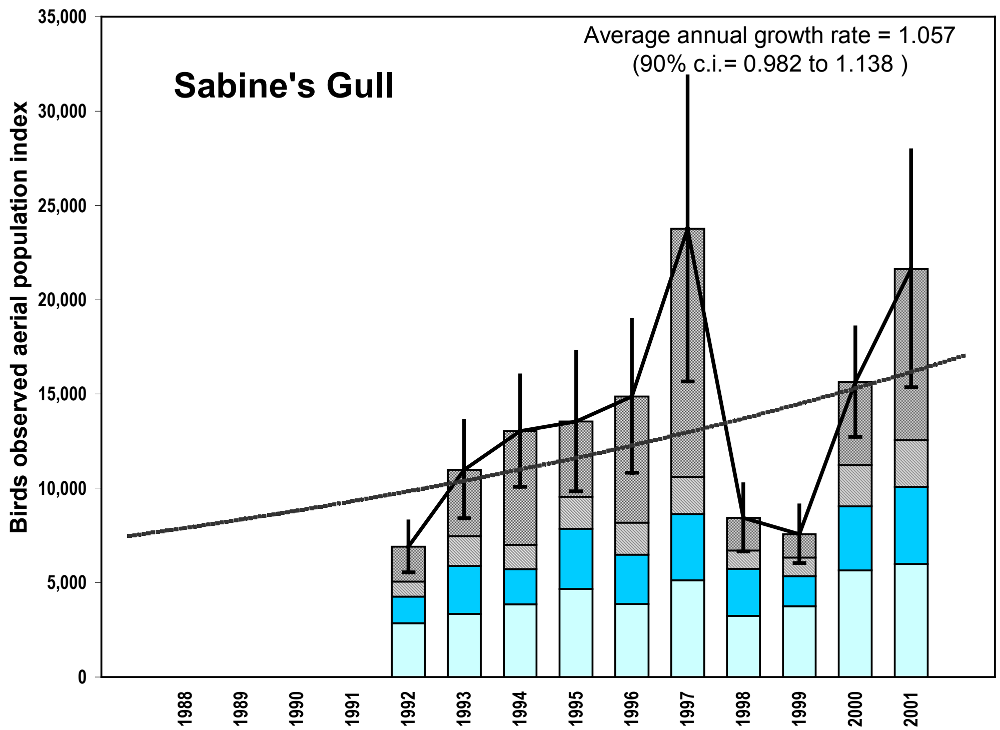

Fig. 21. Population trend for Sabine's Gulls (*Xema sabini*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

year	Estimated birds observed as: sg	2*pr	flks<5	lg flks	Sg+2*pr index	SE	Birds observed index	SE
1988								
1989								
1990								
1991								
1992	5,816	1,936	598	3,064	7,752	614	11,414	1,865
1993	6,820	3,518	997	1,696	10,337	868	13,031	1,319
1994	7,226	4,240	1,015	3,166	11,467	746	15,648	1,391
1995	9,347	3,424	975	4,626	12,771	1,115	18,372	3,301
1996	7,133	2,922	814	2,292	10,055	1,022	13,161	1,696
1997	9,802	2,934	1,449	5,662	12,737	944	19,848	3,866
1998	8,585	3,348	1,226	7,254	11,933	1,239	20,413	5,317
1999	6,757	3,548	598	595	10,304	798	11,497	952
2000	9,995	4,678	681	4,751	14,674	1,014	20,106	3,559
2001	9,592	4,580	1,613	1,873	14,173	1,153	17,659	1,577
avg =	8,107	3,513	997	3,498	11,620		16,115	

	Sg+2*pr		Birds observed	
log-linear slope =	0.045	SE=.015	0.037	SE=.024
Prob >Ttest =	0.020		0.156	
power (with alpha at .1) =	1.000		0.750	
min. slope detectable in 14 years =	0.026		0.047	
n years to detect a -0.069 slope =	5.239		7.702	
regression residual error CV =	**0.140**		**0.216**	
average sampling error CV =	**0.082**		**0.147**	
		90%c.i.		90%c.i.
average annual growth rate =	**1.046**	1.02 - 1.073	**1.038**	.998 - 1.079
avg. growth rate, last 5 yrs =	**1.043**	.967 - 1.124	**0.975**	.845 - 1.126

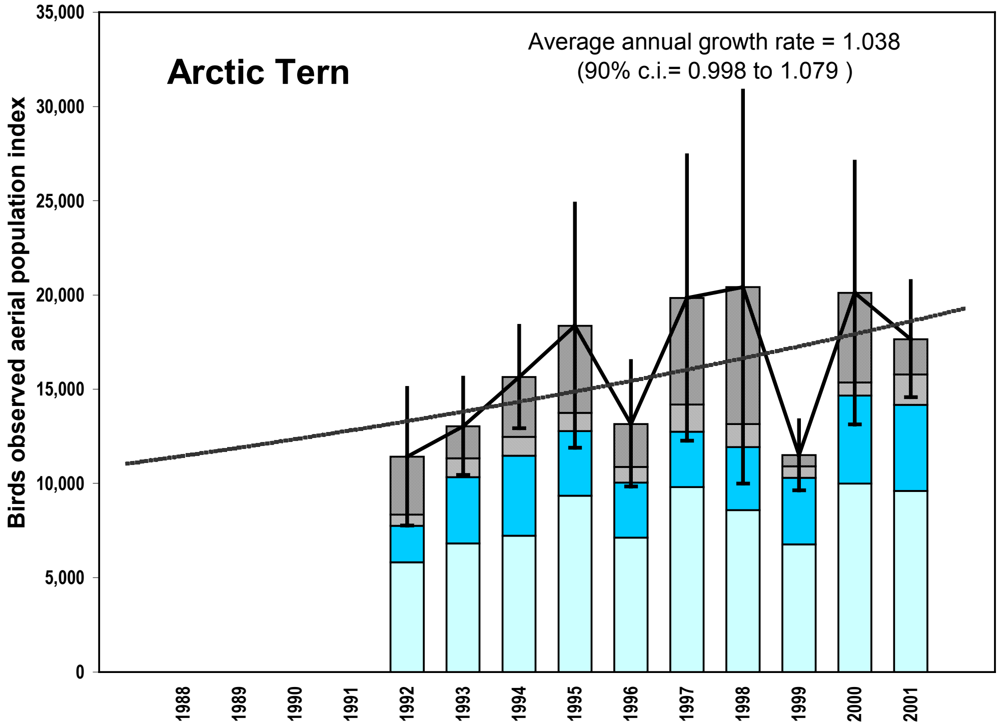

Fig. 22. Population trend for Arctic Terns (*Sterna paradisaea*) observed during waterfowl surveys on 12,832 km^2 of coastal wetlands on the Yukon-Kuskokwim Delta in western Alaska. The total birds observed aerial population index is the sum of singles, birds in pairs, birds in flocks of 3 or 4, and birds in large flocks, as indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on within-year sampling error among transects as stratified by 18 physiographic regions. Average annual growth rate is determined by log-linear regression. Power calculations use alpha and beta levels set at 0.10 and a coefficient of variation based on the averaged annual estimates of sampling error.

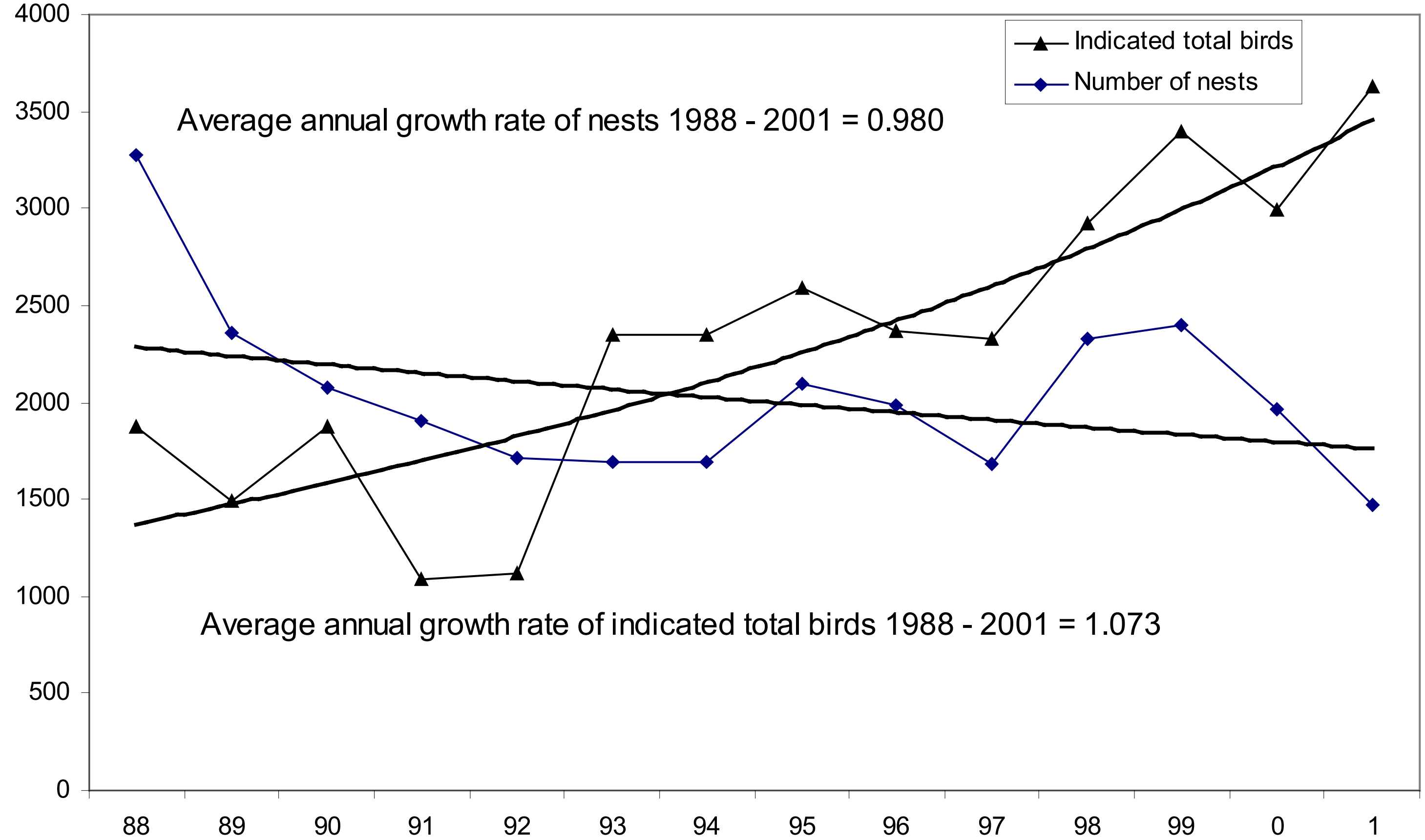

Fig. 23. Population estimates and trends for spectacled eider nests from the ground-sampled area (Bowman et al. 2001) and indicated breeding birds from aerial surveys of the Yukon Delta coastal zone, 1988 - 2001.